SCIENCE

VOL. 86 FRIDAY, DECEMBER 24, 1937 NO. 2243

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal
Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

VITAMIN DEFICIENCY EXPERIMENTATION AS A RESEARCH METHOD IN BIOLOGY[1]

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VITAMINS are organic substances, not related chemically to one another, indispensable to normal functioning of some one or more animal species. They are effective in small amounts, do not furnish energy, are not structural materials as the fats, carbohydrates and proteins, but are necessary for the chemistry of cells. Our knowledge of them came through discoveries that substances of plant origin—the vitamins or provitamins of to-day—are essential for the well-being of many animals. Species not requiring a given vitamin in their diet may have the power of synthesizing it from elementary compounds, as has been proved for the rat in the case of vitamin C. Absence of a vitamin results in the suspension, in all probability, of a single type of intracellular chemistry necessary for the tissue concerned, and indirectly, for the organism as a whole. One of the outstanding results of the attempts of Howe and myself to achieve morphological characterizations of the vitamin deficiencies was the discovery that cells deprived of a function essential for the organism as a whole may, nevertheless, survive and multiply.

We have endeavored to find the initial tissue or cellular responses to each vitamin deficiency with the belief that the cells first to exhibit changes would be those in which the vitamin was necessary for the performance of an essential chemical process. In some instances we have succeeded for the requirements of a morphological characterization, but with all members of the B group, B_1 and the B_2 components, we have failed, possibly because the chemistries involved are common to many tissues and concern energy processes

[1] DeLamar Lecture, the Johns Hopkins University, School of Hygiene and Public Health, May 11, 1937.

not involving structural maintenance and hence unaccompanied by distinctive morphological changes. Thus far we have not resorted to intensive cytological studies, beyond investigating the behavior of mitochondria in several of the deficiencies (A, C and the G complex) in each instance with negative results.

The steady progress in understanding of the biochemistries of the vitamins now obtainable in pure form is a challenge to the cytologist because in some instances it should be possible to determine the loci, within cells, of vitamin activities. The opportunity of associating chemical activities or functional rôles with nuclear and cytoplasmic structures appears to be at hand.

My endeavor to-day is to review our material in exposition of the possibilities of the vitamin deficiencies and related repair phenomena as a technique of research of fairly wide interest in morphological fields.

VITAMIN A

Observations made on many vertebrate species indicate that vitamin A is presumably indispensable to all vertebrates. "So far as known, no vertebrate can synthesize carotenoids *de novo*."[2] The first observable consequences of its absence is the atrophy of epithelial structures and, in many locations, replacement by stratified keratinizing epithelium identical in appearance in all locations and arising from proliferation of basal cells.[3, 4, 5] This occurs in the ducts of many glands, in glands themselves and in many mucous membranes. Not all epitheliums show this effect. The mucosa of the stomach and intestines and the renal tubules show practically no change. When it occurs, the atrophy progresses to a state wherein the cells, although having the appearances of viability, become inert in physiological activities and in their rôles of covering membranes. An invariable sequence in pathology is that a break in continuity of a tissue is followed by reparative proliferation, hence the basal cells normally concerned in maintaining the integrity of epithelium respond by active mitotic division. As the basal cells are focally distributed in all non-stratified epitheliums, the next stage in the progress of the deficiency is the appearance of scattered foci of proliferative activity beneath the original epithelium. The new (reparative) cells, by their continued growth undermine and replace the original epithelium and, regardless of previous function and morphology of the region, develop into a stratified keratinized epithelium. This replacement epithelium is identical wherever it occurs and comparable in all its layers with epidermis. Apparently mature epithelial cells which possess power to multiply in addition to their physiological activity in behalf of the organism as a whole, do not respond to vitamin A by keratinizing metaplasia. The best examples of this are liver and renal tubule epitheliums. One explanation may be that such cells have no activity dependent upon a supply of vitamin A. Another may be that these cells can adapt to the deficiency by virtue of potentialities retained with the power of division. Why the reparative activities of basal cells of many different epitheliums in vitamin A deficiency lead to a common product—an epidermis-like structure—can not be answered unless a keratinizing epithelium represents a more primitive type than those having secretory activities. The fact that in vitamin A deficiency certain stratified epitheliums, the transitional epithelium of the urinary tract and the corneal epithelium become hyperkeratotic indicates that these covering membranes have unknown functions which, when suppressed, are accompanied by a diversion of energy into another channel—a more rapid growth with the simpler chemistry of keratinizing epithelium.

In recovery which follows restoration of vitamin A to the diet, in spite of the complete morphological masking, the epithelium in each region returns to its normal type.[6] By instituting repair, we can start at will the differentiation of the stratum germinativum towards the normal epithelium of the region. The minute cytological changes which may accompany this shift have not been adequately searched for. Early in the reparative process, a line of demarcation appears separating the cell layer where differentiation toward keratinization has progressed to an irreversible stage from cells below which have retained the complete potentialities of the region. It is apparent that the potential characteristics of the masked epithelium reside only in the cells with power to divide. This line of demarcation in repair is produced by vacuolar degeneration of the cells accompanied by infiltration with leucocytes. The cells above are either cast off or disintegrate. The cells of the lower stratum proceed to differentiate directly into the normal type and, because desquamation has ceased, with a lower rate of division.

The only normal process which involves a mechanism similar to those in recovery of epitheliums in A deficiency is that of the changes in the vagina of rodents during the estrous cycle. Here the sequences involved in the periodic cornification of the vaginal mucosa bear some resemblance to those of vitamin A

[2] G. Wald, *Jour. Gen. Physiol.*, 19: 351, November, 1935.

[3] S. B. Wolbach and P. R. Howe, *Jour. Exper. Med.*, 42: 753, December, 1925.

[4] S. B. Wolbach and P. R. Howe, *Arch. Path. and Lab. Med.*, 5: 239, February, 1928.

[5] K. D. Blackfan and S. B. Wolbach, *Jour. Pediat.*, 3: 679, November, 1933.

[6] S. B. Wolbach and P. R. Howe, *Jour. Exper. Med.*, 57: 511, March, 1933.

deficiency metaplasia, while the sequences of the reverse changes are very similar to recovery changes in vitamin A deficiency, including vacuolar degeneration, leucocytic infiltration and desquamation. As the metaplasia of vitamin A deficiency and its recovery is a cycle that probably does not occur in animals in natural habitats, it is of interest to find that it can be correlated with normal processes. Comparison of the A deficiency phenomena with the histological sequences in the estrous cycle makes us note that the greatest similarity exists between vitamin A reparative sequences and the sequences in the di-estrous. Hence, the addition of vitamin A in the deficiency produces results like those presumably due to the wane of an hormonal effect.

Vitamin A, in its effect upon epithelium and in its repair, offers two opportunities to identify physiological shifts with structural detail.

The biochemistry of vitamin A is practically unknown except in its rôle as a constituent of visual purple. Here it is a necessary material for the making of a photosensitive compound, a conjugated protein with vitamin A in the prosthetic group which, in undergoing changes due to light, initiates nerve impulses. A supply of vitamin A is necessary for the resynthesis of visual purple. Important facts to consider are that visual purple is a vitamin-protein compound and that in this instance vitamin A is a structural material and that profound cytological changes are wide-spread in many organs in the deficiency. These facts suggest that vitamin A may be solely concerned in maintaining an apparatus within cells and not in the chemical processes for which the apparatus is necessary.

The most interesting consequences of vitamin A deficiency are found in the incisor teeth of rats and guinea pigs because these structures grow at a fairly rapid rate throughout the life of the animal and because the leading rôle in the organization of the tooth at the formative end is played by the enamel organ, an epithelial structure which in vitamin A deficiency atrophies and undergoes keratinizing metaplasia.[7] The enamel organ atrophy is followed by atrophy and loss of polar deposition of dentine matrix on the part of the odontoblasts—cells of mesenchymal origin. The odontoblasts remain morphologically normal and functionally active on the labial side of the tooth in apposition to the enamel organ long after complete disappearance upon other surfaces. (The enamel organ is found on the labial side of the tooth only, except at the formative end of the tooth, where it exists as a sheath extending about 1 mm from the base.) With complete enamel organ atrophy in the rat, the odontoblasts disappear also on the labial side. For a considerable time, however, the odontoblasts survive. They lose their columnar shape but continue to deposit dentin, no longer restricted to the outer pole, but in centrifugal fashion like osteoblasts. Therefore, we have characterized the odontoblast as a polarized osteoblast and regard the enamel organ as the polarizing agent. Ultimately in complete A deficiency, all activities of the odontoblasts cease, formation of dentin stops, and inclusions of enamel epithelium occur through plication occasioned by stress of the imperfect dentine. The inclusions are carried forward as the tooth grows.

In repair following vitamin A administration, the organizing influence of these enamel epithelium inclusions is shown by the formation of odontoblasts from adjacent connective tissue cells of the pulp. The recent production, by means of long-continued vitamin A deficiency by Burn, Orten and Smith, of Yale, of tumor-like formations and tooth duplications at the formative end of rat incisors reveals much more strikingly the possibilities of this technique for the study of sequences of cell differentiations and organogenesis.[8]

Whereas vitamin A deficiency shows the dependence of odontoblasts upon the enamel epithelium, complete atrophy of the odontoblasts in vitamin C deficiency has no effect upon the enamel organ. Enamel organ changes, attributed to scurvy, are caused by trauma due to the loosening of the teeth consequent to resorption of anchoring structures, fibrous and bony.

In guinea pigs in vitamin A deficiency, the rapidity and completeness of enamel epithelium atrophy are greater than in white rats. Before the atrophy is complete, globules of calcified material are deposited between the enamel organ papillae and upon the tooth surface of the organ. This occurs less strikingly in rats. In guinea pigs, such deposits may pile up until broad sheets of cementum-like material are formed. I am certain that this deposit does not begin in dead cells. It is found in the region of greatest vascularity of the enamel organ. The cells directly responsible for the elaboration of a specific calcified structure enamel are partly or completely inactive. A reasonable explanation of the deposit of calcified material is that capillaries continue to deliver the inorganic ingredients of enamel to the tissues and thus give evidence for a selective permeability of the capillary walls or of functional activity on the part of the endothelium. The high mineral content of enamel and its rapid growth rate present problems concerning concentration that make such speculations attractive.

Another consequence of vitamin A deficiency, but common to any athrepsia which may prove useful in

[7] S. B. Wolbach and P. R. Howe, *Am. Jour. Path.*, 9: 275, May, 1933.

[8] A. N. Orten, C. G. Burn and A. H. Smith, *Proc. Soc. Exper. Biol. and Med.*, 36: 82, February, 1937.

studies of endochondral bone growth is that growth of bone ceases because of cessation of proliferative activity of the epiphyseal cartilage. A narrow band of atrophic cartilage is the result which becomes bounded by a thin plate of bone on the diaphyseal side duplicating conditions also normally found in adult rats. In recovery from vitamin A deficiency, the cartilage regenerates, blood vessels from the diaphyseal marrow penetrate the limiting bony plate, and normal endochondral bone formation is resumed. Resumption of bone growth may be induced in vitamin A deficient rats who have become chronologically adult while under the deficient regimen. Of course, the effect may be due to release of hormones as a part of the secondary recovery phenomena.

Finally, in the consideration of vitamin A deficiency, I mention that, associated with the anemia, there is in comparison with other vitamin deficiencies a heavy deposition of hemosiderin in the liver and particularly in the spleen. In recovery, following an outburst of erythroblastic activity in spleen and bone marrow, the hemosiderin rapidly disappears from the organs, which may be regarded as presumptive evidence that the stored iron is utilized.

VITAMIN C DEFICIENCY

In 1926, Howe and I characterized the condition of scorbutus as the inability of the supporting tissues to produce and to maintain intercellular substances.[9] These conclusions were reached through histological studies of human infantile scurvy and largely through studies of the histological sequences of progressing scurvy in growing guinea pigs and of the repair following administration of vitamin C in natural forms. Subsequently, further verification that vitamin C was the only missing factor in scorbutus, concerned in the inability of the tissues to produce intercellular material, was obtained through the study of reparative processes following the oral and parenteral administration of crystalline ascorbic or cevitamic acid.[10] The intercellular substances requiring ascorbic acid for their formation and maintenance are the collagen of all fibrous tissue structures, the matrices of bone, dentine and cartilage, and probably all non-epithelial cement substance, including that of the vascular endothelium. The relation of ascorbic acid to elastic tissue has not been studied. The reparative proliferative powers of epithelial cells, endothelium, fibroblasts and osteoblasts are not impaired. The mechanism of calcification is not interrupted.

Cells which produce intercellular substances may undergo striking morphologic changes. Such cells, notably the freely dividing osteoblasts in periosteum and at sites of endochondral ossification, migrate away from recently formed bone and assume the appearances of young fibroblasts. In long-continued partial vitamin C deficiency in animals receiving inadequate rations of ascorbic acid, striking accumulations of connective tissue cells may build up, notably at attachments of muscles to bones and fasciae. This I interpret as a compensatory hyperplasia, occasioned by mechanical weakness due to diminished collagen production.[11]

As a tool of investigation, I have used C deficiency and repair to study the manner and source of collagen formation, taking advantage of the fact that the repair of blood clots in guinea pigs in absolute scorbutus is by avascular organization and that fibroblasts wander far from their sources and remain isolated in the blood clot.[12] No collagen is formed until ascorbic acid is administered. This affords means to study the appearances and staining behavior of collagen at various periods following the initial deposit. It appears first as a homogeneous material in which argyrophile or reticulum fibrils promptly follow. Coincidentally, with the appearance of the argyrophile fibrils, the stains in common usage for demonstrating collagen show the presence of collagen fibril bundles. The distribution of the collagen is dependent upon the form of the cell and with isolated cells is confined to zones immediately adjacent to the cell body and its processes, including the entire length of fibroglia fibrils.

The course or direction of the collagen and argyrophile fibrils is parallel to surfaces of the fibroblast and its processes. Because of this arrangement and the absence of a radiating pattern, collagen fibril formation must be influenced by factors unlike those operative in the formation of fibrin strands. The pattern of fibrils formed rapidly in groups of cells without processes suggests that it is determined by the resultant of forces acting in the homogeneous or amorphous stage of collagen formation, presumably influencing the alignment of the elongated collagen molecules. The sequences of collagen formation and the appearance of the fibroblasts, before and after the effect of ascorbic acid is apparent, indicate that collagen is a secretory product of the cell and is laid down extracellularly. Neither fibrin nor any other surrounding material enters into its composition, as has been claimed by various investigators.[13]

In the repair, or rather the resumption of normal growth of bone, the sequences of bone matrix or osteoid formation can be followed. The first appear-

[9] S. B. Wolbach and P. R. Howe, *Arch. Path. and Lab. Med.*, 1: 1, January, 1926.

[10] V. Menkin, S. B. Wolbach and M. F. Menkin, *Am. Jour. Path.*, 10: 569, September, 1934.

[11] Unpublished.

[12] S. B. Wolbach, *Am. Jour. Path.*, 9: Supplement 689, 1933.

[13] J. Nageotte, "L'organisation de la matière dans ses rapports avec la vie." Felix Alcan, Paris, 1922.

ance of the matrix are identical with those of collagen formation, including the formation of fibrils. Subsequently, the material characterizing osteoid is added. By observation of the character of intercellular material deposited about the cells in the "gerüst mark" zone of scorbutic bones, it has been possible to show that these cells having the appearance of immature fibroblasts are in reality osteoblasts, in corroboration of my observation that, in the development of scurvy, osteoblasts applied to newly formed bone trabeculae of the primary spongiosa of endochondral bone formation assume the morphology of fibroblasts and migrate toward the marrow.

The most striking and immediate effect of C deficiency in incisor teeth of guinea pigs is upon the odontoblasts. Dentine matrix formation becomes atypical. An excessive amount of material is produced. This material for a time is probably a rarefied matrix; later the appearances indicate that it is a liquid. The pulp becomes shrunken and the layer of atrophic odontoblasts becomes much folded and widely separated from the old dentine. Following the administration of vitamin C, the gap between the wall of dentine and the shrunken pulp rapidly becomes filled with dentine matrix. The layer of new and normal-appearing dentine matrix formed within a few days may exceed in thickness the original tooth wall.

In bone as well as in incisor teeth we see evidence that in complete vitamin C deficiency, cells concerned in the formation of matrices continue to secrete a material which is liquid in character. This is our interpretation of the edematous appearance of the "gerüst mark" zone in experimental scurvy. The volume and rapidity of osteoid formation (about osteoblasts which have masqueraded as fibroblasts) during repair in this zone are as impressive as are the reparative sequences in teeth. Further support to this interpretation of observed sequences is that the fibroblast in the avascular organization of lesions in absolute scurvy are vacuolated with a material faintly stainable by the anilin blue method. Many observations lead to the conclusion that the rôle of ascorbic acid in synthesis of intercellular materials concerns the gelling quality of a product which is liquid up to its passage through the cell wall. In absolute scurvy this product remains liquid and may gel promptly when recovery is instituted. It should not be beyond ingenuity to put this hypothesis to direct test. As far as can be judged from microscopic appearances, the amount of intercellular substances formed suddenly in repair of absolute scurvy and in long-continued incomplete C deficiency bears a quantitative relationship to the amount of ascorbic acid administered.

That vitamin C is concerned in the maintenance of intercellular materials may be inferred by the lesions of scurvy in consequence of weakness of fibrous tissue structures and the occurrence of osteoporosis independently of osteoclasis and in the presence of undisturbed Ca : P metabolism. Study of bones undergoing osteoporosis in absolute scurvy has offered evidence that some liberated bone cells survive and increase in size and acquire appearances usual to fibroblasts. Fibroglia fibrils can be seen in enlarged bone canaliculae and to extend into the enlarged marrow cavity. Traces of matrix extending inward from the cortical bone lie parallel to fibroglia fibrils. Thus we can see in reverse order what takes place in the formation of bone.

Without intention, the study of vitamin C deficiency and its recovery phenomena in bone provided almost ideal conditions for testing some of the most important hypotheses of Leriche and Policard.[14] These authors believe that the osteoblast is a degenerated connective tissue cell. They deny that the osteoblast contributes to the formation of bone matrix. Bone matrix, their pre-osseous substance, is collagen ("connective tissue substance") modified by union with a material ("interstitial lymph") of humoral origin. Osteoblasts, wherever situated, including the periosteum, serve to limit or confine bone formation. No secretory product of cells contributes to the formation of bone matrix. They admit release of enzymes from degenerating (osteoblasts) cells, as a possible factor in matrix formation from collagen and humoral substances. Our observations, as outlined above, are in complete disagreement regarding the functions of osteoblasts and bone cells, periosteal bone formation and source of bone matrix.

While cartilage matrix formation ceases in absolute scorbutus and the density of epiphyseal cartilage undergoes marked changes, the responses to the deficiency and to repair are less prompt than with other matrices. Argyrophile fibrils do appear in the first matrix formed during repair. As far as I can determine, no appreciable amount of fibrillary collagen is laid down as in bone formation. Fibroglia fibrils do not persist and I doubt if they occur at any stage in the development of the cartilage cell from the perichondrium or from cells of an early callus *following* fracture.

Extramedullary hematopoiesis is not an uncommon finding in the experiences of pathologists. In the scorbutic guinea pig it occurs in the neighborhood of extensive hemorrhages of spontaneous origin, notably in the wall of the urinary bladder beneath the mucosa. In tissues adjacent to blood clots formed after excision of skeletal muscle, islands of erythroblastic cells are found about capillaries and apparently are derived

[14] R. Leriche and A. Policard, "Les Problems de la physiologie normale et pathologique de l'os." Masson et Cie., Paris, 1926.

from vascular endothelial cells which accumulate in consequence of failure of capillary formation. The erythroblastic activity is increased after administration of vitamin C. More intensive studies than I have made are necessary to establish beyond doubt that the capillary endothelium has embryologic potentialities and is the source of blood-forming cells.

VITAMIN D

The rôle of vitamin D, whether or not identical with the pure substance, calciferol, or viosterol, in the processes concerned in the deposition of calcium phosphate in bone matrix is not clear, particularly in relation to the experimental production and cure of rickets in white rats. In the absence of vitamin D, proper amounts and ratios of calcium and phosphorus in the diet prevent rickets, yet vitamin D cures rickets produced in the rat by dietary methods. Likewise, restoration of a proper calcium and phosphorus intake is curative. According to Shohl, "The essentials for the production of rickets are an inadequacy of vitamin D accompanied by a relative deficiency of calcium or phosphorus or an absolute deficiency of either or of both."[15]

Rickets is exhibited in two striking ways. First in importance is the chemistry involved in the calcification of bone in which vitamin D is operative in maintaining normal concentrations of calcium and phosphorus in the blood. The second is the interruption of cartilage cell sequences necessary to the endochondral growth of bone and logically would seem to be a consequence of the first. Rickets also illustrates beautifully a deficiency condition in which the retardation or suppression of normal processes is expressed by strikingly obvious morphological changes. Also, as in scurvy, there are quantitative relations between morphological effects and intake of the essential dietary factors, by which the degree of the deficiency can be estimated or gauged. In each of these deficiencies, the characterization in terms of interrupted sequences explains completely the gross and microscopic pathology. I shall refer only to the morphological aspects of rickets.

The sequences in endochondral bone formation which are disturbed in rickets may be stated briefly as follows. The epiphyseal cartilage, at the upper end of the tibia for example, in normally growing white rats consists of a narrow plate of cartilage firmly supported by bone on the epiphyseal side and uniformly penetrated by blood vessels of capillary dimensions on the diaphyseal side. Very little evidence of growth is present at any one time on the epiphyseal side where bone is closely applied in the form of transverse trabeculae or a thin fenestrated plate.

Growth is accomplished by continuous proliferation of cartilage cells, arranged in columns, on the epiphyseal side and simultaneous degeneration at a corresponding rate on the diaphyseal side. The cavities occasioned by the degeneration and disappearance of the cartilage cells at the diaphyseal end of the columns are invaded by capillaries accompanied by cells (osteoblasts) which are responsible for the deposition of bone matrix upon the exposed cartilage matrix. Endochondral growth of bone is thus achieved by a continuously retreating gap in the continuity of tissues, a gap maintained on the epiphyseal side by a continuous renewal of cartilage cells and repaired on the diaphyseal side by vascular ingrowth comparable to repair of a defect of tissue by the process of organization or granulation tissue formation. Since the ingrowth of capillaries is secondary to or dependent upon the degeneration of cartilage cells, the advantage of the columnar arrangement of the latter is apparent as a factor in securing orderly growth of bone. In normal growth there presents, on the diaphyseal side of the marrow epiphyseal cartilage, a continuous layer of clear or empty cartilage cells forming an almost straight line.

The first histological evidence of rickets is the absence in whole or in part of the layer of clear cells and the consequent absence of ingrowth of capillaries. The thickness of the epiphyseal cartilages increases because the normal cycle of proliferation and degeneration of the cartilage cells has been interrupted at the end stage. Proliferation and differentiation continue to maturity, but there is no degeneration and hence no opportunity for capillaries to enter. Death of the cartilage cells is an essential to growth of bone, yet this complete degeneration is differentiation carried to an extreme, for it is of indispensable service. Not only does it permit the ingrowth of capillaries, but it is attended by the deposition of calcium salts in the surrounding matrix. Studies of calcification of epiphyseal cartilage in normal growth and in the repair of rickets shows that the calcification of the "provisional zone" takes place coincidentally with the degeneration of the cartilage cells and only in the matrix surrounding cells which show very evident morphological aspects of degeneration.

The dependence of endochondral bone formation upon proliferation, differentiation, and degeneration ending in death and disappearance of the cartilage cells illustrates and epitomizes *cytomorphosis* in its four essential stages as defined by Minot.[16]

We may then contemplate endochondral bone for-

[15] A. T. Shohl and S. B. Wolbach, *Jour. Nutrition*, 11: No. 3, 1936.

[16] C. S. Minot, *The Popular Science Monthly*, August, 1907.

mation as expressive of the general cytomorphic law operative throughout embryonic development and the whole life of the organism. To quote Minot: "Cytomorphosis, the succession of cellular changes which goes on in the body, is always progressive. It begins with the earliest development, continues through youth, is still perpetually occurring at maturity, and in old age. The rôle of the last stage of cytomorphosis, that is of death in life, is very important, and its importance has only lately become clear to us."

Other than rickets and its repair, I know of no clean-cut method of manipulating cytomorphic sequences.

In vitamin A deficiency, in the keratinizing metaplasia, we see the substitution of one expression of this law for the usual. In rickets, apparently through changes in the calcium and phosphorus concentration in the blood, we suspend cytomorphosis and no mechanism appears for the disposal of superfluous cartilage cells. Perhaps the accumulation of osteoid (bone matrix) which occurs around capillaries in the diaphysis adjacent to the cartilage is another expression of suspended cytomorphosis for normally only a small part of the primary spongiosa of bone survives. One may speculate that non-calcified bone matrix has, in an ontogenetical sense, never given occasion for the development of a process of removal and hence in rickets it remains until it has fulfilled its destiny of calcification, then removal of the excess is initiated.

Resumption of cytomorphosis is the first visible effect in the repair of rickets and is shown by the degeneration of the cartilage cells on the diaphyseal border. These probably are the oldest cells, they are cells in closest proximity to blood vessels, and therefore the first to be influenced by a change in chemical environment. This reparative effect takes place promptly and is clearly evident within twenty-four hours. Also, within twenty-four hours there is calcification of the matrix lateral to these cells and ingrowth of blood vessels into the empty cartilage spaces has begun.

The first osteoid to become calcified in repair is that laid down in the resumption of normal sequences. The osteoid that has accumulated in the diaphysis during the deficiency later becomes calcified and then only is mostly removed by osteoclasis.

It would be interesting to follow the effects of mechanical stresses upon the pattern produced by osteoclasis in the removal of the calcified excess osteoid in repair of advanced rickets. The rapid rate of the renewed growth of bone makes it seem possible that we have at hand a convenient tool for the study of effects of stresses in the architecture of cancellous bone.

The degree or severity of rickets may be estimated and recorded on the basis of the prominence of anatomical changes demonstrable by roentgenograms or histological study. Obviously, two factors enter into the production of the pathological picture, the duration of the deficient diet and the degree of the deficiency as measured by calcium and phosphorus blood concentrations and ratios. Either factor can be made the variable and thus the time factor can be calibrated against the chemical factor, in so far as increased width of epiphyseal cartilage and accumulation of osteoid are concerned.

DISCUSSION

I have sketched the important morphological consequences of the vitamin deficiencies I know best. I have tried to learn about others and have refrained from presenting bits of information about them which, though interesting, are not now amenable to correlation with known normal sequences.

Vitamins must have other activities than those expressed by morphological changes, but those I have considered are undoubtedly concerned with the maintenance of structure. Biochemistry and morphology meet in the field of vitamin research, and together promise new progress in the understanding of the organization of the cell and of tissues.

Of value in using vitamin deficiencies as a method of investigation is the fact that in repair the released activities for a time proceed at a rate greater than the normal. This is proved by the measured rate of increase in size and weight in recovery from A, B_6, and lactoflavin deficiencies and is very evident in the histological sequences in recovery from C and D deficiencies. Details of growth of bone, for example, are easier to follow than in the normal because of the rapidity of processes and the accurate correlation in time that is possible.

Thus far only the obvious morphological consequences of the vitamin deficiencies have been studied by simple techniques. Minute cytological studies will probably bring to light much new information of value. Experimental scurvy and rickets, I believe, offer to the combined attack of biochemist and pathologist the best approach to urgent problems in the physiology and pathology of intercellular substances and in particular, collagen.

Modification of form and function of cells in vitamin deficiency may be of value as premises in problems, hitherto approached only by the methods of experimental embryology, concerning the differentiation of tissues and perhaps the ideas expressed in the term "dependent differentiation" as contrasted to "self-differentiation."[17] Hormones have forced their way into the horizon of embryologists and vitamins will follow, for they too are agents having profound effects upon cells designed to respond. Vitamins are essential for the conversion of metabolites into energy and

[17] P. Weiss, *Physiol. Rev.*, 15: 639, October, 1935.

secretory products, and hence indirectly as well as directly are concerned in maintenance of normal structure. Conceivably the "fields" under vitamin influence include cells other than those in which vitamins operate.

I acknowledge a hazy embryological perspective and admit my vagueness of ideas, yet it seems to me that the morphological responses to vitamin deficiencies should in a very limited way influence thought in research upon embryonic organization and, in particular, postnatal differentiation of tissues. More limited perhaps in possibilities for such purposes than the hormones, the vitamins offer more direct attack or easier isolation of phenomena in forms amenable to research.

A number of problems involving cells and tissues primarily affected by vitamin deficiencies can be made easier of approach by making use of the facts that we can retard, suppress and release at will some tissue activities, including growth of cells, source, maintenance and formation of intercellular materials, calcification of bone and cartilage, compensatory hyperplasias, and other applications, all of which have been mentioned in their appropriate setting.

The observations submitted may seem trivial in relation to the broad front of attack upon the problems indicated, but none the less they are interesting and thought-provoking. For the *how* of vitamin deficiency consequences, demonstrated morphological sequences only can be offered; for the *why*, retreat to two refuges or expedients I have long employed in teaching—certain invariable histological sequences in pathology and the conviction that all pathological processes subsequent to injury recapitulate normal events of growth.

AWARD OF THE MEDALS OF THE ROYAL SOCIETY[1]

By Sir WILLIAM BRAGG
PRESIDENT OF THE ROYAL SOCIETY

SIR HENRY DALE is awarded the Copley Medal. His most important contributions to physiology and pharmacology lie in two different but closely related fields: (1) the isolation of certain chemical substances, notably histamine and acetylcholine, from animal tissues, and (2) the discovery of the part played by these in a large number of important physiological and pathological processes.

His earlier work (1905–11) on the active principles of ergot led to progress in many allied subjects. The study of histamine, isolated from ergot extract and later found as a normal constituent of certain tissues, has modified profoundly our views of the capillary circulation and of the conditions known as "wound shock" and "anaphylactic shock." In 1914 he became interested in the choline esters, and with extraordinary prescience singled out acetylcholine as the most interesting member of the series and pointed out the extreme likeness of its action to that of stimulating the parasympathetic.

In 1924, Loewi demonstrated that a substance indistinguishable from acetylcholine is liberated by the heart when the vagus nerve is stimulated. The researches of others, prominently among them Dale himself and his colleagues, have since shown that acetylcholine is liberated at many other junctions between conducting tissues, and the results with acetylcholine and adrenaline are embodied in the description of nerves as "adrenergic" and "cholinergic." Recently convincing evidence has been given by Dale and his collaborators that acetylcholine plays an important, possibly an essential, part in the transmission of impulse from nerve to voluntary muscle: a discovery which has direct practical bearings on muscular fatigue and in various pathological conditions, and also is of the greatest interest in the theory of the mechanism of the nervous and neuromuscular systems.

As director of the National Institute for Medical Research, Dale has inspired and directed a wide variety of investigations outside his special field, and numerous investigators from many countries have worked under his guidance.

A Royal Medal is awarded to Professor Nevil Vincent Sidgwick. He has always been primarily interested in the causes which determine molecular structure, and his earlier experimental work chiefly dealt with such subjects as tautomerism, and the vapor pressures, boiling-points and solubilities of isomerides. The development of the conception of the nuclear atom, more particularly by Bohr and Moseley, made possible for the first time a quantitative treatment of chemical valency other than purely formal, and the first steps in this direction were taken by Langmuir, G. N. Lewis and Kossel during, or just after, the war. Others followed with theoretical or physical extensions.

Sidgwick's post-war experimental work has all been concerned with particular problems of structure, utilizing to the full available physical methods of attack. To take a few examples, he has shown the existence

[1] Made at the anniversary meeting, Burlington House, London, November 30, 1937.

of coordination compounds of the alkali metals, and has demonstrated the coordinating properties of the hydrogen atom. In particular, it was he who distinguished clearly the existence of a third and very important type of chemical binding, the so-called coordinated covalent link.

In 1927, he published "The Electronic Theory of Valency," in which, for the first time, the most diverse structural phenomena covering the whole field of chemistry were rationally systematized. The book met with immediate and enthusiastic acceptance in all quarters. In 1928, he played a leading part at a conference held at Munich to discuss chemical binding in its relation to atomic structure. In 1931, he lectured in the United States of America. His second book, "The Covalent Link in Chemistry," which appeared in 1933, is based on the course then given and, like the first, has proved effective and stimulating to a high degree. In late years he has continued his work of fruitful interpretation in a series of remarkable contributions made to the Annual Reports of the Chemical Society, and in his recent presidential addresses to the same society on the subject of "Resonance Phenomena in Chemistry."

A Royal Medal is awarded to Dr. Arthur Henry Reginald Buller. He was professor of botany in the University of Manitoba from 1904 to 1936. His original contributions to science are mainly in the field of mycology and have been published in his "Researches on Fungi." Six volumes of these researches have appeared, the first in 1909, the sixth in 1934, and he is now engaged in the preparation of further volumes.

These researches fall into two groups. The first comprises studies on the morphology, biophysics and physiology of the higher fungi, including the physiology of the mycelium and the organs produced on it, and especially of the production and liberation of spores. The second group deals with sex in the higher fungi, and his studies on this subject rank among the most important that have been made. Particular mention should be made of his observations on the process of diploidization in the higher fungi, and of the discovery, in conjunction with his student Craigie, of heterothallism in the rusts. This work has revolutionized our conception of the life cycle of these forms. Buller's studies have not been confined to one group of fungi, but include researches on Discomycetes and many groups of the Eu-Basidiomycetes, as well as on rusts and smuts. Reference should also be made to his "Essays on Wheat" and to his efforts which made possible the publication of the translation by his friend, W. B. Grove, of the monumental "Selecta Carpologia Fungorum" of the brothers Tulasne.

During his thirty-two years of occupation of the chair of botany at Winnipeg, he has been a leading figure in Canadian botany, and was president of the Royal Society of Canada in 1927 and 1928. Since his retirement he has continued his researches in this country.

The Davy Medal is awarded to Professor Hans Fischer. During the past twenty-five years he has been continuously engaged in the study of the chemistry of the porphyrins, the bile pigment and chlorophyll. Starting from the knowledge that the porphyrin molecule was built up of pyrrole nuclei, variously substituted in the different porphyrins, Fischer developed controlled methods of degradation which extended the possibility of the identification of the pyrroles contained in any given porphyrin.

With the accurate information acquired in this manner as a basis Fischer proceeded, by bold and original synthetic work, artificially to prepare a large number of porphyrins of known structure, many of which proved to be closely related to or identical with natural products; his crowning achievement in this field was the synthesis of protoporphyrin, which, with iron, yielded haematin identical with that derivable from blood haemoglobin.

From the porphyrins Fischer turned his attention to the bile pigments and was able to explain the fundamental chemical features of their relationship to haemoglobin, thus paving the way for the biochemical work which is now proceeding in other laboratories and which promises to explain the actual mechanism of bile pigment formation in the body.

In recent years Fischer has applied his brilliant synthetic technique with outstanding success to the elucidation of the detailed structure of chlorophyll; his work in this field continues at the present time.

The Buchanan Medal is awarded to General Frederick Fuller Russell. He graduated from Columbia College of Physicians and Surgeons in 1893, and began his career as a member of the Medical Corps, U. S. Army, in 1898, advancing through the various grades to that of colonel in 1917. He resigned in 1920. He was curator of the Army Medical Museum, Washington, D. C., from 1907 to 1913, and also instructor in bacteriology and clinical microscopy at the Army Medical School, where he performed distinguished service in developing and producing the typhoid vaccine which the Army has used with great effectiveness since that time. He was professor of pathology and bacteriology at George Washington University School of Medicine from 1909 to 1913 and for the following year lecturer in tropical medicine at the New York Post-Graduate Medical School and Hospital. From 1915 to 1917 General Russell was

chief of the Board of Health laboratory in Ancon, C. Z., and during the world war was in charge of the division of infectious diseases and of the laboratory service of the surgeon-general's office, U. S. Army. From 1920 to 1923 he was director of the public health laboratory service of the International Health Board, and from 1923 to September 1, 1935, he was general director of the board. In 1919 he received the Distinguished Service Medal. Recently he was appointed lecturer on preventive medicine and hygiene and epidemiology at Harvard Medical School, Boston.

It was during the period while General Russell was director of the International Health Division of the Rockefeller Foundation that the foundation gave such material aid towards the establishment of schools of hygiene in various European countries. They also contributed largely to the All India Institute of Hygiene in Calcutta and to the Singapore Medical School. General Russell was also responsible for establishing the yellow fever unit in West Africa. Large grants were given to the Health Section of the League of Nations, and the fellowship scheme under the International Health Division was considerably extended. The policy of the foundation in these matters was moulded in no small degree by General Russell, whose influence on the development of public health services all over the world has been altogether remarkable.

The Sylvester Medal is awarded to Professor Augustus Edward Hough Love. He is most generally known as the author of the "Treatise on the Mathematical Theory of Elasticity," which has attained a universal reputation and remains the standard work of reference on this subject all over the world.

Before the first edition of the treatise was published in 1893 (almost simultaneously with the completion of the publication of Todhunter and Pearson's "History of Elasticity"), this branch of mathematical physics received little attention, and its results were often regarded by engineers with suspicion. During the intervening years it has gradually established itself as one of the most reliable mathematical theories of continuous media and, unlike its sister science of non-viscous hydrodynamics, its results have been increasingly verified in practice. That this has come about is due in great part to the influence of Love's "Treatise," which, indeed, like Lamb's "Hydrodynamics," is far more than a mere treatise and embodies a vast amount of original work.

In other of his published work there is a great volume of research dealing not only with elasticity, but with hydrodynamics and electromagnetism. His earlier work was mostly on hydrodynamics, particularly vortex motion and wave-motion. He returned also at various times to electrical problems, especially those relating to the propagation, scattering and transmission of electric waves. His elastical investigations range over an exceedingly wide field, from the equilibrium of beams and plates of various shapes to the study of vibrations in a variety of difficult cases and to the applications of the theory of elasticity to problems connected with the earth.

An enumeration of Love's researches, even when restricted to the more important ones, would be too long to attempt in this brief account; but two of them may be explicitly mentioned.

The first of these is the powerful and elegant theory of the support of the continents, of earth-tides and seismic waves and of the elastic stability of the earth, developed in his Adams Prize Essay of 1911, "Some Problems of Geodynamics," where appears for the first time his explanation of the seismic waves vibrating horizontally and transversely to the direction of propagation, waves to which Love's name is now universally attached.

The second is the remarkable paper on biharmonic analysis in a rectangle, published in the Proceedings of the London Mathematical Society in 1929. In this paper Love gives a complete solution of the biharmonic equation subject to given boundary conditions over the perimeter of a rectangle, thus solving at any rate the two-dimensional form of a problem which was described by Lamé as "le plus difficile peut-être de la théorie de l'élasticité," and had till then baffled mathematicians.

The Hughes Medal is awarded to Professor Ernest O. Lawrence, professor of physics in the University of California, the inventor (1932) of the cyclotron, the most important instrument of physical research since the C. T. R. Wilson expansion chamber. By its means ions are accelerated in a magnetic field and move within two half-cylinders which change electrical polarity in rhythm with the circulating ions, so that deuterons have been spirally speeded in a vacuum to velocities due to three million volts. These deuterons, impinging on beryllium, have produced neutrons and protons in great number, and some of the protons have been projected through the equivalent of forty centimeters of air. Many elements have been proved to be radioactive when thus bombarded by high-speed protons or deuterons.

Hydrogen molecular ions have been used also as bombarding elements with velocities due to five million volts. Such high-speed ions are available for developing the theory and practice of atomic disintegration, and Professor Lawrence and his co-workers are playing a leading part in this development.

NEW SOCIETIES AND SHIFTING INTERESTS

By Professor HENRY B. WARD
UNIVERSITY OF ILLINOIS

THE history of the American Association for the Advancement of Science records many instances in which that organization has laid foundations on which a new scientific society has been built up in some special field, and illustrates also that in the passing years it has shown that plasticity and power to change readily and effectively which characterizes successful organisms. The approaching meeting at Indianapolis brings to mind one episode in the history of the association which deserves recounting at this time. This is its relations to the American Microscopical Society, which at Indianapolis will be meeting in the same city in which it was organized sixty years ago next summer. At the foundation of the movement which led to the organization of that society, the American Association played so large a part that it may rightly be regarded as the parent society here as it has been in many other cases.

In the 1870's and 80's the country saw the establishment of many local natural history clubs devoted to the field study of biology. At about the same time there arose another series of societies devoted to the study of the microscope and its revelations of the minute in life. Hardly one of the larger cities was without its microscopical society locally famed for its journal and an annual exhibition of apparatus and mounted specimens. Among the mid-western states Indiana displayed general enthusiasm for developing public interest in natural history through such local clubs, museums and societies.

Indianapolis was the natural center for such activities in the state, and the local interest had been stimulated by a very successful meeting of the American Association for the Advancement of Science held there in 1871, of which more later. Seeking to arouse wider interest and to promote the advancement of microscopical science, the Indianapolis Lyceum of Natural History in May, 1877, addressed the various microscopical societies in the United States regarding the formation of a national organization in this field. The receipt of numerous favorable replies led to the circulation of a call for an organization meeting at Indianapolis in August, 1878.

This gathering, which was designated the National Microscopical Congress, extended its sessions over five days—August 14 to 19. Fifty delegates were present from some 40 microscopical societies, distributed over the country from the eastern seaboard to the Pacific coast. Four days were needed to complete the program of papers covering a wide variety of subjects and an inspection of instruments and specimens. The interest manifested was such that it was then decided to perfect the formal organization of a national society. A constitution was adopted, officers elected, and the body adjourned to meet in Buffalo a year later. To this organization was given the name of the American Society of Microscopists. However, the congress at Indianapolis has regularly been regarded as the first meeting of the society and is so listed in its early publications. The name persisted in the form just given until the organization met in Washington, D. C., in August, 1891. At the close of that meeting it was incorporated in the District of Columbia under the name of the American Microscopical Society and has carried this designation since that time.

Dr. Richard Halsted Ward, of Troy, N. Y., served as president of the National Microscopical Congress at Indianapolis in 1878 and at its close was elected as first president also of the newly established American Society of Microscopists. Reluctant to remain in office, he resigned, but the members refused to accept his withdrawal and he served the new society at its first meeting held at Buffalo the following summer. The society in making this choice was no doubt influenced by the fact that Dr. Ward had been active in the section on microscopy in the American Association, which had manifested for several years marked interest in this relatively new field of science.

A rereading of the older records shows clearly that the American Association had already taken an active part in developing the field of microscopy. The proceedings of the Salem, Massachusetts (1869), meeting record that the local committee sent out in May a *Special Circular to Persons Interested in the Use of the Microscope*. This circular announced that in order to encourage the use of the microscope, suitable rooms would be provided for an exhibition of microscopes, old and new, accessories, test objects and other related scientific materials. Several pages in the proceedings of the Salem meeting are devoted to a brief description of these exhibits in a report signed by Edwin Bicknell, "Secretary of the sub-section of Microscopy." This sub-section was probably established by the standing committee of the association, which had authority for such action, though I have found no printed record to verify my surmise.

In the Proceedings of the Troy (N. Y.) meeting in 1870, the constitution as printed provided for a subsection on (3) Microscopy under Section A, which included otherwise (1) Mathematics and Astronomy,

(2) Physics and Chemistry. This volume contains an extended report on the microscopes and microscopical apparatus exhibited at the meeting. The report begins, "In accordance with the custom initiated at the Salem meeting," so one may safely consider the Salem exhibit and discussion as the start in the formal development of microscopy under the auspices of the American Association. The report was signed by R. H. Ward, secretary of subsection on microscopy.

This subsection appears again in the constitution printed in the *Proceedings* of the Indianapolis meeting in 1871. The list of officers for that meeting includes a sectional committee as well as chairman and secretary for this subsection and the last paper in the printed volume is entitled "On Uniformity of Nomenclature in Regard to Microscopical Objectives and Oculars," by R. H. Ward. But I have found no further evidence of sessions, programs or an exhibition on that occasion.

At that period subsections appear to have been temporary and were called into service only occasionally. In the following meeting at Dubuque, this was the only subsection to hold a session and have a program. Dr. Ward was chairman. At Portland in 1873 officers were listed but no activities recorded. A new constitution was promulgated at Hartford in 1874, and no mention of microscopy appeared anywhere in the new document or in the records of the meeting. But the recently developed interest, though eliminated for the moment, was only temporarily suppressed. A year later (1875) in the record of the meeting at Detroit is found the brief statement, "Informal action was taken by a number of members specially interested in Microscopy, in favor of the formation at the next meeting of a Subsection or Association Club similar to that of the Entomologists" just organized there.

Accordingly, the account of the Buffalo meeting held in 1876 records that under Section A a permanent subsection on microscopy was organized, with R. H. Ward as chairman and E. W. Morley as secretary. Some papers were read and general interest in the work of the subsection awakened. Elsewhere it is stated that the Buffalo Microscopical Club held meetings during the week to which those interested were invited.

At Nashville in 1877 the permanent subsection on microscopy was in full swing. Again at St. Louis in 1878 this subsection had its place; its officers were listed and the titles of papers read appear in the program. This activity was shown, despite the separate meeting at Indianapolis in that year and the organization of a special society. However, a shift in emphasis was soon apparent.

The subsection on microscopy when first organized in 1869 and immediately thereafter concerned itself primarily with principles of optics and improvements in apparatus and methods. It was accordingly subordinated to Section A, which dealt with physics, mathematics, etc. Later the programs embraced more and more papers on biological topics, to which the sectional programs were entirely devoted at Boston in 1880 and Cincinnati in 1881. Before the latter meeting the constitution had been again revised and nine sections replaced the earlier two. Here Section G, Histology and Microscopy, replaced the older subsection and functioned actively until at the Ann Arbor meeting in 1885 it was fused with Section F, Biology, and the title Microscopy disappeared from the schedule of the American Association.

For ten or a dozen years after the organization of the separate microscopical society, its programs included much material on apparatus and methods. Gradually the development of apparatus passed into the hands of inventors and manufacturers and as the field of investigation broadened, methods were particularized and lost wide general interest. Hence this material also was left out. So to-day the work of the American Microscopical Society centers around the material studied rather than apparatus or methods.

OBITUARY

WILL SCOTT

April 20, 1877, to October 17, 1937

DR. SCOTT'S early academic training at Indiana State Teachers College, Terre Haute, qualified him as a high-school teacher, and for several years he taught in the New Augusta and Bloomington high schools. His first association with Indiana University came in 1902, when he enrolled in the summer session at the Biological Station and which he subsequently attended each summer until 1907. He received the A.B. and A.M. degrees in 1908 and the Ph.D. degree in 1911. His first university appointment, as a fellow in zoology engaged in a study of cave plankton, was granted in 1907, and from that time until his death he held the following university positions: instructor, 1908–1911; assistant professor, 1911–1919; associate professor, 1919–1921; professor, 1921–1937. He was appointed director of the Biological Station in 1920. He was a member of Phi Beta Kappa, Sigma Xi, American Society of Zoologists, Ecological Society, American Association for the Advancement of Science and the Indiana Academy of Science. He served as president of the Indiana Academy of Science in 1935.

Dr. Scott's first scientific publication was an "Eco-

logical Study of the Plankton of Shawnee Cave," and his view-point in all his succeeding scientific work remained primarily that of an ecologist. The late Dean Eigenmann influenced his early biological training, but Dr. Scott also developed independently a very broad outlook on problems of fresh-water biology. Much of his research in later years was devoted to various aspects of lake and river morphometry and sedimentation, as well as more strictly biological phenomena. He was especially interested in the problems which were concerned with the productivity in fresh water, and he accumulated in the course of his studies extensive physical, chemical and biological data on nearly one hundred Indiana lakes. In cooperation with his students he also surveyed and collected similar data on the Tippecanoe and White Rivers. Since he was interested in the practical application of his findings as well as in pure science, he was able, from time to time, to cooperate with the Indiana State Department of Conservation on problems of a practical nature.

At the time of his death he was making a study of the scales of game fish in order to determine the relation between age, feeding habits and reproduction. This meant that extensive contacts had to be made with sportsmen throughout the state and their help enlisted in the collection of material. The very excellent response which followed his request for material was evidence of the very high esteem in which he was held and also indicated his ability to interest laymen in scientific problems.

Dr. Scott was quite informal in his teaching and endeavored to reach the superior student rather than the average undergraduate, and the advanced student found in his classroom the stimulus of delightful personal contact. Dr. Scott drew his lecture material from his personal experience as well as from a wide knowledge of diverse fields, and the conservative way in which he presented his information remains as an ideal scientific attitude to challenge his colleagues. Will Scott exerted a profound influence upon the development not only of his own students, but also on all those who came to know him during their formative years as graduate students. A kindness which dulled the sharp edge of criticism and a willingness to help at any time were characteristic of the man, and he leaves behind many who feel keenly the loss of a personal friend.

W. R. BRENEMAN

DEPARTMENT OF ZOOLOGY,
INDIANA UNIVERSITY

RECENT DEATHS

DR. JACOB JOSEPH TAUBENHAUS, chief of the division of plant pathology and physiology of the Texas Agricultural Experiment Station at College Station, died on December 13 at the age of fifty-three years.

HAROLD T. EDWARDS, research associate in the Fatigue Laboratory at Harvard University, died on December 14 at the age of forty years. His interests were mainly in the physiology of muscular exercise and in the effects of high altitude.

DR. GEORGE HENRY FALKINER NUTTALL, emeritus professor of biology at the University of Cambridge and lately director of the Molteno Institute for Research in Parasitology, died on December 16 at the age of seventy-five years.

PROFESSOR C. GRAVIER, professor of zoology in the Muséum national d'Histoire naturelle, Paris, died on November 14 at the age of seventy-two years.

DR. HANS MOLISCH died on December 8 at the age of eighty-one years. He had been a professor of botany in the Universities of Vienna, Praha and of Sendai, Japan, and had done research work in the United States, India and Java.

DR. GUSTAF DALEN, head of the Swedish Gas Accumulator Company, inventor and industrialist, to whom was awarded the Nobel Prize in physics in 1912, died on December 9. Dr. Dalen invented the system of acetylene lighting used in lighthouses throughout the world. The sun valve he perfected permits the light beam to be turned on and off automatically at unmanned lighthouses. He was blinded by an explosion the year he received the Nobel award, but continued his work.

SCIENTIFIC EVENTS

GEOLOGICAL EXPEDITION TO LAKE MEAD OF THE CARNEGIE INSTITUTION

THE Carnegie Institution of Washington-California Institute of Technology geological expedition, which left Lee's Ferry, Arizona, early in October for a traverse of the Grand Canyon of the Colorado, has just completed a successful trip to Lake Mead. The party consisted of three boats and eight men: Drs. Ian Campbell and John H. Maxson, of the California Institute of Technology; Dr. J. T. Stark, of Northwestern University; E. D. McKee, park naturalist of Grand Canyon National Park; R. P. Sharp, formerly of the California Institute and now Woodworth traveling fellow at Harvard University, and three experienced boatmen, Frank B. Dodge, Owen Clark and M. F. Spencer.

The expedition was planned primarily to continue studies of the Archean formations which had been

carried on for several seasons by Drs. Campbell and Maxson under the auspices of the Carnegie Institution. A river trip was necessary in order to visit sections inaccessible by pack train from the rim. Work in the Granite Gorges was greatly facilitated by the excellent topographic maps of Matthes, Evans and Birdseye and by the careful geological reconnaissances of Noble and Moore.

The final results of the present trip must wait for laboratory examination of rock specimens under the microscope, which may to some extent modify the interpretations of field observations. Among the latter, however, may be tentatively listed:

1. The recognition of many primary structures in the Archean (Vishnu) schists, establishing definitely their origin as dominantly sedimentary.

2. The tracing of isoclinal folds across regional schistosity of the recrystallized sediments by means of bedding outlined by biotite concentrations along lines of fracture cleavage and by the presence of pegmatite and quartz stringers following lines of drag folds in the schists.

3. The close folding, repeating many times the Vishnu series in the Canyon, instead of a single, large, open fold involving an extremely thick series of the old schists, as formerly thought.

4. The presence of a large amount of amphibolite schists, which are so intimately intercalated with the sedimentary schists, that a water-lain, tuffaceous origin is suggested; and a lesser amount of cross-cutting amphibolite, assumed to represent old basic intrusions.

5. The record of two magmatic invasions, possibly separated in time but probably emanating from the same batholithic chamber underlying the Canyon section. The larger magmatic invasion was migmatitic in character, while a smaller granitic mass was somewhat more mafic, due to stoping and assimilation of amphibolitic country rock. A later series of pegmatite and aplite dikes cut the granites and schists, and represent the last event of Archean history in the Canyon sections.

Besides the detailed work in the Archean sections there was opportunity also for some observations on the continuity and changes in the lower Paleozoic formations; for some data on late inter-canyon lava flows; and for structural studies including the mapping of new faults and the recognition of repeated movement along many of the old fault zones.

Much credit is given to the boatmen for their skillful work, which left the geologists of the party free for scientific observations the greater part of the time.

THE SECTION OF GEOLOGY OF THE TENNESSEE ACADEMY OF SCIENCE

THE first meeting of the Section of Geology of the Tenessee Academy of Science was held on Friday afternoon, November 26, 1937, at the time of other section meetings of the forty-first meeting of the Tennessee Academy of Science at George Peabody College for Teachers in Nashville. Professor L. C. Glenn, of Vanderbilt University, a charter member of the academy, presided. Thirty-seven members and visitors attended the meeting.

On Saturday afternoon and Sunday (November 27-28) the section, under the leadership of C. W. Wilson, Jr., of Vanderbilt University, and Kendall E. Born, of the Tennessee Division of Geology, sponsored a geologic field trip into the Wells Creek Basin, a typical cryptovolcanic structure in southeastern Stewart County. The Wells Creek Basin, the largest of the American cryptovolcanic structures, consists of an intensely disturbed area of approximately 9 miles square. At the center of the disturbance the Knox dolomite of Cambro-Ordovician age is brought up through the St. Louis (Mississippian) limestone, a vertical displacement of more than 1,000 feet. Formations of Cambro-Ordovician, Ordovician, Silurian, Devonian and Mississippian ages are involved, many of which are not exposed elsewhere in Middle Tennessee. Sunday was spent in the examination of some of the more complex structural and stratigraphic aspects of this unique area.

On Saturday afternoon, *en route* to Wells Creek Basin, the following points of geologic interest were visited: Block faulting in North Nashville; Silurian, Devonian and lower Mississippian sections on the western flank of the Nashville dome; and a typical Tuscaloosa (Upper Cretaceous) outlier on the western Highland Rim.

Twenty-one members and visitors from six states were present on this field trip.

THE ANNUAL MEETING OF THE NEW YORK ACADEMY OF SCIENCES

A. CRESSY MORRISON, industrial chemist, chairman of the advisory committee of the Hayden Planetarium at the American Museum of Natural History, was elected president of the New York Academy of Sciences, the oldest scientific society in New York City, at the one hundred and nineteenth annual dinner of the academy held on November 15.

Twenty-nine members were elected fellows of the academy and honorary members were elected as follows: Dr. Orpen Bower, botanist of the University of Glasgow; the Rev. Pierre Teilhard de Chardin, S.J., paleontologist, of the Cenozoic Research Laboratory, China; Dr. D. Obrutschew, geologist, of the Soviet Academy of Sciences, Leningrad; Dr. Charles Palache, mineralogist of Harvard University; Dr. H. Spemann, embryologist, of the University of Freiburg, and Dr. Franz Weidenreich, director of the Cenozoic Research Laboratory.

In an address made after the elections, Dr. Barnum Brown, curator of fossil reptiles at the American Museum of Natural History, described his research last

summer in the so-called "dinosaur bowl," near Rock Springs, Wyo., and in the coal mines of Colorado.

Dr. Horace W. Stunkard, professor of zoology at New York University, the retiring president, delivered an address entitled "Parasitism and Evolution as Illustrated by Some of the Lower Forms of Life."

The A. Cressy Morrison Prizes of $200 each were awarded to Robert H. Denison for a paper on paleontology and to Raymond L. Zwemer and F. H. Pike for their paper on the effect of nerve excitation on potassium in body fluids.

Announcement was made that two prizes of $200 would be awarded by Mr. Morrison in 1938 for the best papers in a field of natural science, and that there would be an additional prize of $500 for the best paper on scientific developments relating to the source of the sun's energy.

Officers elected in addition to Mr. Morrison are: Ida H. Ogilvie, Herbert Johnson, Irving Lorge, Harry L. Shapiro, *vice-presidents;* Wyllys R. Betts, Jr., *treasurer;* Frederick H. Pough, *recording secretary;* Dr. Stunkard, *corresponding secretary;* G. Kingsley Noble, *librarian;* John H. Barnhart, *editor;* Dr. Brown and A. T. Poffenberger, *councilors,* and Herbert F. Schwarz, John D. Sherman, Jr., and Wayne M. Faunce, *members of the finance committee.*

SYMPOSIA OF THE AMERICAN CHEMICAL SOCIETY

A THREE-DAY symposium on the "less familiar chemical elements" sponsored by the Division of Physical and Inorganic Chemistry of the American Chemical Society, will be held at Cleveland, beginning on December 27. Professor Harold S. Booth, of Western Reserve University, is chairman of the division.

There are thirty-one papers on the program covering technological, scientific and economic developments concerning the rarer elements, including beryllium, tungsten, molybdenum, tantalum, columbium, indium, lithium, rubidium, gallium, cesium, selenium, germanium, rhenium and osmium.

M. J. Rentschler, general manager of the J. H. R. Products Company, Willoughby, Ohio, will be the chief speaker at a banquet on the evening of December 28, at the Hotel Statler, headquarters of the meeting. His subject will be "One of the More Familiar of the Less Familiar Elements." In addition to the papers to be read before the technical sessions there will be a symposium at 8 A.M. on Monday, December 27, at which Dr. J. Papish, of Cornell University, will discuss the non-terrestrial occurrence of the less familiar elements, and B. F. Scribner of the National Bureau of Standards will point out their occurrence in everyday materials; H. C. Meyer, president of the Foote Mineral Company, Philadelphia, will outline their economics, and Dr. E. G. Zies, of the Geophysical Laboratory, Washington, D. C., will describe their concentration through igneous and related activity.

An industrial trip to the General Electric Company Wireworks is scheduled for Tuesday afternoon, December 28. The manufacture of tungsten and molybdenum wire from ore, and the separation and purification of argon will be demonstrated. Tours will be made on Thursday morning through the inorganic chemistry division of the Morley Chemical Laboratory of Western Reserve University, where the manipulation of fluoride gases will be illustrated; the research laboratories and color department of the Harshaw Chemical Company; and the laboratories of the Ferro Enamel Corporation. An exhibition will be arranged at the Hotel Statler.

At the seventh national organic chemistry symposium of the society to be held in Richmond from December 28 to 30, leading organic chemists will report progress in research dealing with vitamins, proteins and carbohydrates, synthetic drugs, refrigerants and the structure of other carbon compounds. Seventeen colleges and universities and three research laboratories will be represented by the addresses given.

Dean Frank C. Whitmore, of the Pennsylvania State College, who will take office as president of the society on January 1, will be one of the opening speakers on Tuesday morning, December 28. Professor I. A. Updike, of Randolph-Macon College, will give the address of welcome. Dr. Robert R. Williams, chemical director of the Bell Telephone Laboratories, will discuss the chemistry of thiamin, or vitamin B, the "beriberi vitamin," the structure of which he discovered after twenty-five years of effort. Professor Roger Adams, of the University of Illinois, past president of the society, will be present at the meeting and will read a paper describing the structure of gossypol, the toxic principle of cottonseed, at the Tuesday afternoon session.

Six reports on microchemistry will be presented on Tuesday evening. These have been arranged by Professor Alsoph H. Corwin, of the Johns Hopkins University; Dr. Lyman C. Craig, of the Rockefeller Institute for Medical Research, and Dr. Walter R. Kirner, of the Carnegie Institute of Technology, chairman of the Microchemical Section.

Dr. Max Bergmann, of the Rockefeller Foundation, will be the chief speaker at a dinner meeting on Wednesday. His subject will be "Protein Structure in Relation to Biological Problems."

OFFICERS OF THE AMERICAN CHEMICAL SOCIETY

DR. CHARLES A. KRAUS, professor of chemistry and director of chemical research at Brown University,

has been elected president of the American Chemical Society for 1939.

Dr. Kraus will take office as president-elect on January 1, 1938, at which time Dean Frank C. Whitmore, of the Pennsylvania State College, becomes president of the society, succeeding Dr. E. R. Weidlein, director of the Mellon Institute of Industrial Research, Pittsburgh. Dean Whitmore has been president-elect during the past year. The new president-elect was chosen by the council from four nominees receiving the largest number of votes in a national poll by mail of the members. Three directors and four councilors were also elected by mail ballot. They are:

Directors

Dr. Erle M. Billings, of the Eastman Kodak Company, Rochester, N. Y., reelected from the second district, comprising New York and New Jersey.

Professor Hobart H. Willard, of the University of Michigan, reelected from the fifth district, comprising Illinois, Indiana, Michigan and Wisconsin.

Dr. Gustavus J. Esselen, president of Gustavus J. Esselen, Inc., Boston, Mass., reelected director at large.

Councilors at Large

Dr. William Mansfield Clark, De Lamar Professor of Physiological Chemistry in the Johns Hopkins School of Medicine and holder of the Nichols Medal for his achievements in the fields of oxidation and reduction equilibria, hydrogen-ion concentration and indicators.

Dr. Arno C. Fieldner, chief engineer of the Experiment Stations Division of the United States Bureau of Mines, Washington, D. C., authority on fuels and designer of the ventilating system of the Holland Vehicular Tunnel under the Hudson River.

Professor B. Smith Hopkins, of the University of Illinois, discoverer of illinium, an element of the rare earths group.

Dr. Albert S. Richardson, director of chemical research of Procter and Gamble Company, Cincinnati, and outstanding scientist of the detergent industry.

SCIENTIFIC NOTES AND NEWS

AN authorized life of Lord Rutherford of Nelson is being prepared by Professor A. S. Eve. He requests that those having letters written by Lord Rutherford that might be of use forward them to him at 26 Willow Road, Hampstead, N.W.3.

THE Nobel prizes in physics, chemistry, physiology and medicine and literature were presented at a ceremony held at Stockholm on November 11 by King Gustav of Sweden. Brief addresses were given by Swedish scientific men describing the work of the recipients. All those who had been awarded prizes were present, with the exception of Professor G. P. Thomson, who was kept away by illness.

DR. GANO DUNN, president of the J. G. White Engineering Corporation of New York for twenty-four years, has been awarded the Thomas A. Edison Medal of the American Institute of Electrical Engineers for 1937. The award is made "for distinguished contributions in extending the science and art of electrical engineering, in the development of great engineering works and for inspiring leadership in the profession." The presentation ceremony will be held on January 26 in connection with the annual four-day winter convention of the institute in the Engineering Societies Building, New York City.

THE Institute of Aeronautical Sciences, New York City, observed on December 17 the thirty-fourth anniversary of the first airplane flight by Orville and Wilbur Wright at Kitty Hawk, N. C. Mr. Orville Wright was present at a meeting at Columbia University when the first annual "Wright Brothers Lecture" was given by Professor B. Melvill Jones, of the University of Cambridge. Mr. Wright also attended an "Honors Night" program at the Hotel Biltmore. The Army Aviation Corps observed the anniversary of the first flight when thirty-one planes took off from Mitchel Field as a tribute. The honorary fellowship of the institute was awarded to Dr. Hugo Eckener at a dinner in the Hotel Biltmore. Commander Charles E. Rosendahl accepted the award for Dr. Eckener.

EASTMAN N. JACOBS, aeronautical engineer of the National Advisory Committee for Aeronautics, has received from the Institute of Aeronautical Sciences the Sylvanus Albert Reed award for his work in improving the efficiency of airplane wing sections. The award includes a certificate and a prize of $250.

A GOLD Congressional Medal was presented by President Roosevelt on December 16 to Lieutenant Commander Lincoln Ellsworth in recognition of his Antarctic flight in 1935, during which he claimed 350,000 square miles of territory on behalf of the United States.

A SURPRISE tea in honor of the twenty-fifth anniversary of Dr. T. Wingate Todd as professor of anatomy at the Medical School of Western Reserve University, was given on the afternoon of December 15 by the staff of the laboratory of anatomy. Five hundred leading citizens of Cleveland were present. Before the tea he was presented with etchings and books. Dr. J. E. Hallisy, senior clinical instructor in surgery and anatomy, one of Dr. Todd's earliest students, made the presentation.

EDWARD A. JOHNSTON, vice-president in charge of

engineering and patents of the International Harvester Company, has been elected by the jury of awards of the American Society of Agricultural Engineers as the recipient of the Cyrus Hall McCormick medal for 1938 "for exceptional and meritorious engineering achievement in agriculture."

THE Jackson Dawson memorial medal of the Massachusetts Horticultural Society, for work in the breeding and propagation of woody plants, has been awarded to Dr. Joel E. Spingarn, of New York.

THE council of the Royal Meteorological Society has awarded the Symons gold medal for 1938 to Dr. G. M. B. Dobson, reader in meteorology in the University of Oxford. The medal, which is awarded biennially for distinguished work in connection with meteorological science, will be presented at the annual general meeting of the society on January 19.

THE council of the British Institution of Mining Engineers has awarded the medal of the institution to Dr. Carl Beyling, director of the experimental station at Dortmund-Derne, Germany, in recognition of his services in the application of scientific knowledge and research to industry, with special reference to safety and health problems in coal mining, and to Dr. Richard Vernon Wheeler, in recognition of his services with special reference to problems of safety and health in coal mining and of the utilization of coal. The presentation of the medals will take place at the annual dinner of the institution at Grosvenor House, London, on February 2, at which the German Ambassador will be the guest of honor.

The British Medical Journal reports that on the occasion of the eightieth birthday of Professor Bernhard Nocht, founder of the Institute of Tropical Medicine in Hamburg, medals were awarded to the following in recognition of their services to tropical medicine: Drs. Rodhain, Belgium; Brumpt and Fourneau, France; E. Martini and E. Reichenow, Germany; P. Manson-Bahr and the late G. H. F. Nuttall, Great Britain; Snijders and Swellengrebel, Holland; Bastianelli and Castellani, Italy.

SIR JAMES CRICHTON-BROWNE, M.D., F.R.S., London, celebrated his ninety-seventh birthday on November 29.

DR. RAYMOND FREAS, professor in the School of Medicine at Tulane University, was elected president of the Louisiana Section of the American Chemical Society at the New Orleans meeting. He succeeds James J. Ganucheau. F. A. Irvine was elected vice-president.

THE Columbia Chapter of Sigma Xi has elected the following officers to serve from June 1, 1937, to May 31, 1939: *President,* Professor Harold W. Webb; *Vice-president,* Professor Arthur W. Thomas; *Secretary-Treasurer,* Professor Dana P. Mitchell.

DR. MARVIN C. ROGERS, now chemical engineer in the research laboratory of the Standard Oil Company at Whiting, Ind., has been appointed assistant professor of chemical engineering at the University of Minnesota. At present he is giving a course in the refining of petroleum at the Armour Institute, Chicago.

DR. CHARLES PACKARD, of the Institute of Cancer Research, Columbia University, has been appointed assistant director of the Marine Biological Laboratory, his term of service to begin in January. For the past eleven years, Dr. Merkel H. Jacobs, of the University of Pennsylvania, has served as director of the laboratory, but at the meeting of the trustees last August, he resigned this position to devote his time more fully to research work. The laboratory had an assistant director from the time of its foundation up to the year 1925, when the assistant director, Dr. Gilman A. Drew, resigned; at that time Dr. Jacobs was appointed director, and the place of assistant director has remained vacant.

DR. ARTHUR J. EAMES, professor of botany at Cornell University, is spending this term at the University of Hawaii, his place being assumed by D. M. Weller, who has taught botany at the University of Hawaii for twenty years.

PROFESSOR S. W. PERROTT, who recently retired from the chair of civil engineering at the University of Liverpool, will go to India as lecturer on civil engineering at the Technical College at Ceylon.

E. HARRISON, director of agriculture for Tanganyika, has been appointed professor of agriculture at the Imperial College of Tropical Agriculture, Trinidad.

DR. WILDER PENFIELD, of Montreal, director of the Neurological Institute and professor of neurosurgery at McGill University, will give the fifth E. Starr Judd lecture at the University of Minnesota, on February 2. His subject will be "Cerebral Circulation in Epilepsy." The lectureship was established by the late E. Starr Judd, an alumnus of the Medical School of the University of Minnesota.

DR. E. V. MCCOLLUM, professor of biochemistry at the Johns Hopkins University, gave the Phi Beta Kappa address at Indiana University on December 15. He reviewed present knowledge of the essential nutrients which an adequate diet must provide.

DR. LAURENCE H. SNYDER, of the Ohio State University, addressed the Michigan State College chapter of

Sigma Xi on December 1. His topic was "Heredity and Modern Life."

A WIRELESS dispatch from Moscow to *The New York Times* reports that machinations of "enemies of the people" in the field of astronomy were alleged on December 16 in connection with a meeting of the director of the Academy of Sciences in session in Moscow. As a result Academician V. G. Fesenkoff was summarily relieved of his duties as chairman of the Astronomical Council—a department of the academy —then the council itself was abolished by vote of the academy directors, and its work was turned over to a newly created group under the chairmanship of Professor S. I. Beliavsky. This group was ordered to present a detailed program for astronomical work by January 1. In press reports the council was accused of general inactivity and specifically of inexcusable procrastination in selecting a site for an observatory in the South. Professor Fesenkoff was accused of delivering a vague report of the council's activities, glossing over wrecking done by "enemies of the people."

A ZONING conference was held in Chicago on December 13 and 14 under the auspices of the National Resources Committee. Representatives from every state and from numerous city and county planning groups attended. An entire session of the conference was devoted to a discussion of rural zoning and better land uses, including problems of soil conservation districts, public lands, grazing, roadsides, taxation and forestry. M. L. Wilson, Under Secretary of Agriculture, presided at this session. Flood plain zoning was discussed by Professor H. H. Barrows, of the University of Chicago, and by Abel Wolman, chairman of the Maryland State Planning Board. In general and urban fields the discussions were conducted by Frederic A. Delano and Charles W. Eliot, 2d, of the National Resources Committee, and Dr. Charles E. Merriam, of the University of Chicago. The findings of the conference were summarized at the final session.

Popular Astronomy reports that definite plans have been made for conducting a party of German scientific men on a tour to the United States next summer. The party plans to leave Hamburg on the *Deutschland* on June 30. Fourteen days will be spent in visiting places of interest, including Harvard Observatory, the U. S. Naval Observatory, the Yerkes Observatory, the Bausch and Lomb Optical Works, the Eastman Kodak Company Plant, the Bureau of Standards, the American Museum of Natural History, the Franklin Institute and the large cities directly or indirectly connected with such a tour.

UNDER the terms of the will of the late Francis F. Prentiss, industrialist and philanthropist of Cleveland, a considerable payment of accumulated income has recently been received by the trustees of the Case School of Applied Science, Cleveland, Ohio, and the distribution of the principal is being worked out. After certain specific bequests have been paid, the Case School of Applied Science will receive one tenth of the residue, the ultimate benefits to the school being now estimated at upwards of $600,000. A dividend has been distributed to the professors covering the salary deductions of the last six months. Because of the uncertainty of future income, the trustees have not yet felt able to restore the monthly salaries to the normal scale, but it is hoped that additional dividends may be distributed from time to time.

THE gift by the Anaconda Copper Mining Company to the Montana State University of approximately twenty thousand acres of land not far from Missoula equips the Experiment Station of the university with the most extensive forest holdings of any School of Forestry in the United States and makes possible practical laboratory studies of forest land resources, growth and utilization of timber, lumbering and milling operations, methods of timber production, relationships between forests and water conservation and water flow regulation, between forests and pasturage for domestic livestock and wild life, and related botanical and zoological problems.

BOSTON UNIVERSITY SCHOOL OF MEDICINE has received as a gift from Dr. and Mrs. J. Emmons Briggs their Beacon Street home and other property, the total value of which is said to be $100,000. Dr. Briggs, a Boston surgeon, who graduated from the Boston University School of Medicine in 1890, was professor of surgery there from 1918 until his retirement. He is a trustee of the university and a fellow of the American College of Surgeons.

PROFESSOR JAMES KENDALL, of the University of Edinburgh, has presented the American Chemical Society with the sum of one thousand dollars to continue the American Chemical Society Award in Pure Chemistry for the year 1938. Nominations should be in the hands of the secretary, Dr. Charles L. Parsons, prior to February 5, together with supporting documents as outlined in the rules for the award, which will be found printed, together with Professor Kendall's offer, in the News Edition of *Industrial and Engineering Chemistry* for December 10. The conditions of the award are as heretofore with the exception that the age limit has been increased to thirty-five years and the time for the receipt of nominations extended from January 5 to February 5, 1938.

THE Commonwealth Fund has made a grant of $10,857 annually for a three-year period to the School of Medicine of Western Reserve University for a re-

search on chronic nephritis by Dr. Joseph M. Hayman, Jr., associate professor of medicine.

THERE will be available for the sixteenth International Physiological Congress, to be held in Zurich from August 14 to 18, 1938, several fellowships of $250 each to be awarded by the Committee on International Congresses of the Federation of American Societies for Experimental Biology on the nomination of the councils of the constituent societies of the federation. Applications for these awards should be made to one of the following before January 5, 1938: Dr. A. C. Ivy, secretary, the American Physiological Society, 303 East Chicago Avenue, Chicago, Ill.; Dr. H. A. Mattill, secretary of the American Society of Biological Chemists, State University of Iowa, Iowa City; Dr. G. Philip Grabfield, secretary of the American Society for Pharmacology and Experimental Therapeutics, Harvard Medical School; Dr. Paul R. Cannon, secretary of the American Society for Experimental Pathology, University of Chicago. The awards are subject to the following conditions: Applicants must be under thirty-five years of age and must not have attained university rank above that of assistant professor; each applicant must present the draft of a meritorious paper which he agrees to present to the congress if he receives a fellowship. Applications must be made to the secretary of the society which includes the field of study; applicants need not be members of the federation. Dr. D. R. Hooker, of the Johns Hopkins University, is secretary of the federation.

THE Sigma Xi Committee on Grants-in-Aid, of which W. R. Whitney, Harlow Shapley and Gary N. Calkins are the members, have made the following grants: Professor Alan Arthur Boyden, Rutgers University, $150 for the serological study of the relationship of Crustacea. Professor Leopold Raymond Cerecedo, Fordham University, $250 for the development of a 2-day test for the bio-assay of antineuritic concentrates in mice. Professor Forrest F. Cleveland and Professor M. J. Murray, Lynchburg College, $300 for the Raman effect and molecular structure. Professor Maurice Ewing, Lehigh University, $200 for the geophysical investigations of oceanic basins. Professor George William Hunter, III, Wesleyan University, $250 for studies of the reaction of the host to the penetration of larval parasites. Professor Louallen F. Miller, University of Minnesota, $250 for a study of solar radiation by spherical absorber. Edgar J. Murphy, College of the City of New York, $150 for a study of measurement of x-rays and gamma rays. Professor Jens Rud Nielsen, University of Oklahoma, $200 for a study of Raman spectra and structure of simple polyatomic molecules. Aaron John Sharp, University of Tennessee, $250 for a study of types and distribution of certain bryophytes and spermatophytes.

A DAVID ANDERSON-BERRY GOLD MEDAL, together with a sum of money amounting to about £100, will be awarded in July, 1938, by the Royal Society of Edinburgh to the person who, in the opinion of the council, has recently produced the best work on the nature of x-rays in their therapeutical effect on human diseases. A similar award will be made every three years. Applications may be based on both published and unpublished work. They should be in the hands of the general secretary, Royal Society of Edinburgh, 22 George Street, Edinburgh, 2, by June 1.

DISCUSSION

EFFECTS OF HEAVY WATER ON LIVING CELLS

IN SCIENCE for November 26, under the title "Osmotic Effects of Deuterium Oxide (Heavy Water) on Living Cells," Professor S. C. Brooks reports very interesting experiments which seem to illustrate in living cells the osmotic effect of deuterium oxide deducible from its low vapor pressure. The temporary shrinkage of leaves in deuterium oxide and the hemolysis of D_2O-containing red blood cells when exposed to pure H_2O-salt solution are described. These facts are satisfying corollaries to the lower permeability of erythrocytes to D_2O recently reported independently by both Brooks and Parpart.

In his last paragraph, however, Professor Brooks attempts to illustrate his thesis from the mammalian world by unfortunate examples. Really pure heavy water elicits in mice neither evidences of "thirst" nor "symptoms of distress." In man it produces no "burning sensation" but rather seems to exhibit to some people mild and varying differences in taste from ordinary water.[1]

These contradictions are made advisedly, after nearly three years' experience[2] in the field. Our results have afforded better illustrations of the point made by Professor Brooks. In this laboratory we have, for example, demonstrated in mice that pure heavy water administration causes, on the first day after it is used to replace ordinary water, a definite shift in the water balance to the positive side. This was shown by complete water determinations confirmed by determinations of body weight.[3] A paper now in press[4] illus-

[1] K. Hansen, *Klin. Wochenschr.*, 14: 1489, 1935.

[2] H. G. Barbour, *Yale Jour. Biol. and Med.*, 9: 551, 1937.

[3] H. G. Barbour and Jane Trace, *Jour. Pharm. and Exp. Therap.*, 58: 460, 1936.

trates furthermore the increased tendency of the body to retain water when part of the hydrogen has been replaced by deuterium. A decrease in the insensible water loss relative to the metabolism is described during the period when mice are being raised, either in two days or in five days, to the level of one fifth saturation with D_2O.

It is quite likely, too, that the reversible contraction of *Fundulus* melanophores, which we have also demonstrated,[5] depends partly upon an osmotic factor.

So far as mice are concerned, then, we have yet to find evidence that D_2O "violently" dehydrates living cells. But a number of interesting manifestations of its lower vapor pressure are illustrated by its pharmacological action in mammals.

HENRY G. BARBOUR

YALE UNIVERSITY

THE NON-VOLATILE ACIDS OF THE FRUIT OF NYSSA OGECHE[1]

THE "Ogeechee Lime" appears as a small fruit on the tree *Nyssa ogeche,* which grows in wet ground in the southern states. The fruit which came to the attention of the author was from along the Conoochee River in Georgia. They were light green, olive-shaped fruits, 2.5 to 3.5 cm long with a large single central stone and a thin skin, with cell-walls connecting skin and stone which were firmly attached to the stone, running lengthwise. Forty to 50 per cent. by weight of juice can be expressed by squeezing the fruit. This juice is strongly acidic, but lacks any distinctive flavor. The juice showed about 6 per cent. of acid, calculated as citric. It is said that natives of the regions where they grow use them to make a "limeade" drink and a preserve.

The non-volatile acids were isolated from 100 fruits weighing 637 gm and converted to ethyl esters by the usual method of lead salt precipitation and esterification. A small portion (2 gm) boiled at 150–171° at 10 mm and the remainder boiled at 171–172° at 10 mm (12 gm). The hydrazides of the fractions were prepared. From the low-boiling fraction malic hydrazide, m. p. 176–177° (mixed m. p. 176–177°) was identified. The fraction boiling at 171–172° at 10 mm was citric ester, giving a hydrazide melting at 102–104° when allowed to form spontaneously (hydrated form) and melting at 149–150° when seeded with anhydrous citric hydrazide. It is evident that the principal acid of the Ogeechee lime is citric acid with a small amount of malic.

D. H. WHEELER

[4] H. G. Barbour and Lillie Rice, *Jour. Pharm. and Exp. Therap.,* 1937 (in press).

[5] H. G. Barbour and S. B. Bogdanovitch, *Jour. Pharm. and Exp. Therap.,* 61: 148, 1937.

[1] Food Research Division Contribution No. 348, Bureau of Chemistry and Soils, U. S. Department of Agriculture.

IODOACETIC ACID AND SULFUR METABOLISM

IN view of the suggestions in the literature that iodoacetic acid exerts its inhibitory effect on certain body processes (*e.g.,* absorption, muscle metabolism) by combining with a sulfhydryl compound which may be essential for these processes, experiments have been designed in an attempt to demonstrate *in vivo* a combination of iodoacetic acid with sulfur-containing substances which are of biological importance. Using a technique developed in this laboratory,[1, 2] it has been possible to markedly restrict the growth of young white rats, ingesting a relatively low protein diet, by incorporating suitable quantities of iodoacetic acid in the basal ration. Moreover, the addition of either l-cystine of dl-methionine to the basal diet already containing the iodoacetic acid results in an immediate growth response, and the animals continue to grow at a good rate. This response is striking and appears, to date, to be specific for cystine and for methionine. This study is being actively continued and expanded along the following lines of investigation: (1) To determine the mechanism by which iodoacetic acid appears capable of depleting the sulfur-containing amino acid reserves of the organism; (2) to determine the nature of the *in vivo* combination between iodoacetic acid and these sulfur compounds; (3) to determine the possible relationships of this type of combination to the processes of absorption from the intestine and muscle metabolism.

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AN INTERESTING HOAX PERPETUATED IN AN EARLY SCIENTIFIC BULLETIN

READERS of *Time* for June 7, 1937, were no doubt amused by the article concerning the spider hoax perpetrated by Ralph D. Paine in the 1890's. The article reported that several scientific journals printed the hoax as fact. It may be of interest to know that one of these scientific journals was the *Bulletin of the U. S. Department of Agriculture, Division of Entomology.* The title of the bulletin, which was published in 1897, is "Some Miscellaneous Results of the Division of Entomology." Under "General Notes" on page 82 there is the following sub-head and account:

A NEW DIRECT BENEFIT FROM INSECTS

When Kirby and Spence wrote their chapter on "Direct benefits derived from insects" and recorded the use of insects for food, the use of honey from bees for the same purpose, the use in medicine and the arts and manufacturers of blister beetles, insect galls, Coccidae furnishing lac, wax insects and the silkworm, the time had hardly

[1] A. White and R. W. Jackson, *Jour. Biol. Chem.,* 111: 507, 1935.

[2] A. White, *Jour. Biol. Chem.,* 112: 503, 1936.

arrived for the extensive collection of ants for the manufacture of formic acid or of their pupae as food for song birds, and we feel sure that they could hardly have anticipated an industry which has recently sprung up both in France and Pennsylvania, and which consists of the farming of spiders for the purpose of stocking wine cellars, and thus securing an almost immediate coating of cobwebs to new wine bottles, giving them the appearance of great age. This industry is carried on in a little French village in the Department of Loire, and by an imported Frenchman named Grantaire on the Lancaster Pike, 4 miles from Philadelphia. This Frenchman raises *Epeira vulgaris* and *Nephila plumipes* in large quantities and sells them to wine merchants at the rate of $10 per hundred.

Whoever inserted this note, however, may possibly have done it with his tongue in his cheek. The hoax, as reported in *Time,* mentions a spider named Sara Bernhardt and another named Emile Zola. The above note by omitting these and other details seems to have been pitched lower for its presumably less credulous entomological readers.

DONALD DE LEON

BERKELEY, CALIF.

BIOLOGICAL ABSTRACTS: A CORRECTION

THE chairman of the Periodicals Committee of the American Library Association has called our attention to an error in the statement appearing in last week's SCIENCE. The New York meeting referred to had only *representatives* of various groups present, and one of the constructive proposals made was covered by the first paragraph under "Financing Agreement." It is unfortunate that the statement reads that "it was agreed," when it should have been stated that "it was proposed," etc. The committee chairman writes as follows: "That not even our committee would have the right to agree that librarians would arrange a subsidy for *Biological Abstracts* from their institutions," but that "the chairman of the American Library Association Committee on Periodicals is very eager to come out in support of *Biological Abstracts* if the principle can be established that it is the duty first of the biological organizations and biologists to support financially their own abstracting journals."

THE COMMITTEE ON ARRANGEMENTS
FOR BIOLOGICAL ABSTRACTS

QUOTATIONS

THE PILGRIM TRUST LECTURES

AN informal discussion between the officers of the society and an officer of the National Academy of Washington has led to a very happy result. It was proposed that in alternate years the society should invite and entertain a distinguished lecturer from the United States, and the academy should arrange the converse proceeding. The Pilgrim Trust was consulted on the question of providing the money required for the scheme, and most generously offered a sum of 1,500 guineas, which in the opinion of the trust should provide for suitable honoraria to be paid to the lecturers in six successive years. An exchange of communications between the academy and the society has resulted in the completion of the necessary arrangements, and the first Pilgrim Trust Lecture will, it is expected, be given in London in the coming summer.

Fellows will, I am sure, feel that no more agreeable way of emphasizing the cordial relations between American and British science could have been devised. Although modern communications are so rapid and complete and views spread so quickly, there is a personal character in the research of each man who breaks into a new field, and this interesting and important character can only be communicated by the man himself. In my opinion these lectures should not be mere summaries of past work, nor general discussions of scientific advance. It might be their special feature that they should transfer from one side of the Atlantic to the other new ideas which had already begun to be fruitful and promised wide expansion in the future. Such lectures would associate workers in a common task, and encourage correspondence and the formation of friendships. The choice of lecturers would not be determined on the same plan as the choice for the awards of medals or other distinctions, but would rather bring into prominence the most important lines of advance of the day. The progress of science would be the object of the Pilgrim Trust Lecture, and not the honoring of scientists.

The provision of funds for six years is sufficient to make trial of the plan. If it is successful, as we may be sure it will be, we hope that means for its continuance will be forthcoming.

I am tempted to further hopes. It may be that the universal wish to promote peaceful relations between the nations of the world may find some who are willing to follow the example of the Pilgrim Trust. Of all the enterprises of mankind the acquisition of Natural Knowledge pays least attention to the divisions of men. We have national industries, national trade, national literature, national art, national characteristics, even national religion, but there is only one nature for us to know. One could wish that the seasonal interchange of men to show to other nations what new illumination was dawning in this or that subject of enquiry could be firmly established and honored by the emphatic

recognition of the academies and indeed of the state itself. No greater gift could be made by one people to another than an illuminating idea; it would deserve a people's welcome.—*Sir William Bragg in his presidential address at the anniversary meeting of the Royal Society.*

SCIENTIFIC BOOKS

PROBABILITY

Scientific Inference. By HAROLD JEFFREYS. Reissue with additions. Pp. vii + 272. Cambridge, University Press, 1937. (First published in 1931.)

JEFFREYS treats probability as relating a proposition to another one which expresses the data. He postulates that the probability of p given q be equal to, greater than or less than that of r given s, and that it be maximal or minimal if p is a logical consequence or contrary of q. To these he adds two more postulates (in the Addenda). Then, by way of conventions determining the assignment of numbers to probabilities, he adopts the usual additive law and assigns 1 to logical consequence. From this basis the other usual laws are derived.

But the basis is somewhat vague. In speaking of the probability of p given q Jeffreys presupposes, not a simple relation of p to q, but a binary function; *i.e.*, a triadic relation connecting p, q and some third object figuring as value of the function. These third objects are not numbers, for Jeffreys assigns numbers later. Then what are they? Is "greater than," as applied to them, a further primitive relation? Does its transitivity demand another postulate? Possible adjustment: assume just the tetradic relation, "p is more probable given q than is r given s"; adapt Jeffreys's postulates to this, and add a transitivity postulate.

Further, an anomaly appears in the probability of p given q, where q is a contradiction. In an appendix Jeffreys argues that this probability is indeterminate, rather than 1. But this is in exception to the second postulate above, because p is a logical consequence of any contradiction q. The opposite case, where q is logically necessary, is left unconsidered; we might expect it to yield absolute probability, in some trivial sense.

Jeffreys's decision to treat probability postulationally, rather than definitionally, typifies his general program: formulation, not substantiation. He applies empirical method to empirical method, seeking to isolate a minimum of principles which *would*, if true, justify the scientist's observed behavior. The most notable result is resuscitation of the principle that the probability of a law increases with simplicity—a principle which Poincaré described as long since repudiated. Supposing all quantitative laws expressible as differential equations, Jeffreys proposes measuring their simplicity inversely by the sum of the order, the degree and the absolute values of the coefficients. Whatever other difficulties this theory may involve, one cited by Jeffreys himself is that it requires the totality of possible laws to be denumerable; but on this point his worry seems unwarranted, for the *expressible* laws are in any case denumerable—they form a progression when ordered according to increasing typographical length and lexicographically within each length.

Jeffreys presents and supports Laplace's analysis of the probability of inferences from samples to totalities; stressing, however, that the analysis applies only where we have no prior clue as to how many objects have the investigated property. Closing his statistical studies with an account of the estimation of error, he proceeds to a brief operational analysis of the physical magnitudes. Like Carnap ("Physikalische Begriffsbildung") he construes measurement as assignment of pure numbers to objects, and eliminates the magnitudes themselves, or impure quantities, as mere abbreviative idioms. Unlike Carnap, he insists on the basicness of the additive magnitudes and perceives no convention in the choice of their zero points and scale forms.

In the exposition of number which Jeffreys includes in his analysis of magnitudes, there are remarks (pp. 85, 106) which suggest an over-estimation of Whitehead and Russell's "elimination" of classes. Actually, the so-called propositional functions to which classes are "reduced" are subject like classes to the theory of types, and are indeed the same as classes, except for suspension of the extensionality principle. It is for this reason that classes are accepted as primitive in current logistic, supplanting the propositional functions.

There follows an illuminating treatment of physical geometry, which Jeffreys constructs operationally and then compares with the Euclidean prototype. Then come two useful chapters in which the fundamentals of Newtonian dynamics and relativity theory are formulated from the point of view of methodology. Remaining matters include a brief criticism of the probability theories of Venn, Keynes and others, and some sensible remarks on cause and reality.

The Addenda, appended as the distinguishing feature of this new edition, include indications of the applicability of the simplicity principle in testing the significance of added parameters; also a discussion of the simplicity principle in its rôle of substitute for the traditional postulate of determinism; also some corrections, among them the insertion of two postulates as mentioned above.

W. V. QUINE

WHALES AND SEALS

Naturgeschichte der nordatlantischen Wale und Robben. By E. HENTSCHEL. Handbuch der Seefischerei Nord-Europas, Vol. 3, Part 1, (6) + 54 pages, 60 figs., including 10 plates, 8vo. Stuttgart: E. Schweizerbart'sche Verlagsbuchhandlung, 1937. Price, 11.25 RM.

HENTSCHEL'S "Natural History of the North Atlantic Whales and Seals" forms the first part of Volume 3 of the "Handbuch der Seefischerei Nord-Europas," a volume which is planned to include accounts of animals other than fishes that are of economic importance. The paper is intended to be a convenient guide for the identification of the species of commercial value, and to this end it includes first a short general account of their structural adaptations, followed by a systematic section in which for each species are given the Latin name adopted by the author, the vernacular names in several north-European languages, then the more obvious characters of use in the determination of the species, concluding with brief paragraphs on the distribution, habits, food, reproduction and commercial importance. Nineteen species of whales and porpoises and seven of seals are included. The author purposely omits some of the less common species or genera of cetaceans on the ground that they are of little or no economic interest, yet in a tabular view of this sort it would have been valuable to have included them for the sake of completeness. The genera omitted include Kogia, Mesoplodon, Ziphius, Pseudorca and Prodelphinus, all of which are fairly well known in the North Atlantic. The figures in the text or plates are for the most part reproduced from familiar illustrations and, whether in outline or halftone, should prove helpful in the identification of cetaceans cast ashore or captured, while the seals are well illustrated by figures taken from Wollebaek's account of 1907. A short list of works referred to in the text is given at the close of each of the two sections, and a brief index concludes what should prove a useful résumé.

It is, therefore, a pity that the author did not take equal pains to bring up to date the nomenclature of the cetaceans but persists in the use of many specific names that have long been discarded as untenable by those who have endeavored to establish a correct and stable usage. For nearly a half of the cetaceans listed the specific names are those no longer in use, but one may overlook the occasional failure to follow the current mode in the use of such genera as Sibbaldus for the blue whale or Eubalaena for the southern right whale. The matter may seem of little moment to those primarily interested in other aspects of zoology, but greater care in this respect would go far to establishing a better and more uniform usage where, as in this case, a treatise is intended as a guide for those less familiar with the subject.

G. M. ALLEN

SPECIAL ARTICLES

INTERCEPTION OF RAINFALL BY HERBACEOUS VEGETATION

INTERCEPTION of rainfall by trees, particularly forest trees, has been studied by a number of investigators. Very little is known about rainfall interception by herbaceous vegetation. Such study is of importance for two major reasons. Plants by preventing raindrops from striking the soil directly have a marked effect upon decreasing runoff and erosion. By holding a portion of the rainfall upon the surface of the leaves and stems until it evaporates, a considerable amount of water is prevented from reaching the soil where part of it would eventually be available to the roots of the plants. Thus, there results a very important loss to the vegetation.

In order to determine the magnitude of this loss of water, a series of experiments has been carried on in connection with other ecological work at the University of Nebraska. Numerous methods have been devised, and two have been found which lend themselves readily to field studies with prairie vegetation, crop plants and weeds. A meter quadrat is marked out on the surface of the soil beneath the plants. In it there are placed five pans, each 1 m long, 4 cm wide and 5 cm deep. The surface covered by the pans represents one fifth of the total surface of the quadrat. By means of conveniently spaced, permanent crosswires and a wire mesh in the bottom of each pan, it is possible to place cut plants in the pans in their normal position. When necessary for proper placing of the pans, plants are cut off at the soil surface and inserted in the pans in the same position that they previously occupied. Water is then applied by means of large bottles equipped with sprinkler tops, the amount being expressed as an inch per hour, one-half inch in 30 minutes or in smaller amounts. Such factors as light, air temperature, humidity and wind movement are measured during the progress of the experiment. The amount of water caught in the pans represents one-fifth of the water not held by the plants, and from this it is possible to express the amount of water intercepted in per cent. of the total amount applied.

When working with such mat-forming plants as prostrate pigweed, knotweed, etc., they are cut off at the soil surface and placed in their natural position upon a quarter-inch mesh wire screen one square

meter in area. The screen is then suspended over a large pan and water is sprinkled upon the plants at predetermined rates. The interception capacity of the plants is calculated as before. The effect of wind movement is readily shown by use of an electric fan. Thus the plants are under practically natural conditions. It is not claimed that all the factors which characterize a rain storm are present, but the methods lend themselves to use under such conditions. These experiments were performed during years of extreme drought.

The amount of water intercepted by herbaceous plants is often surprisingly large. Wheat, when fully developed, was found to hold from 50 to nearly 80 per cent. of the water applied, depending upon the rate of application. An open growth of needle grass (*Stipa spartea*) in upland prairie intercepted approximately 50 per cent. of the water applied at the rate of one-fourth inch in 30 minutes. Prairie dropseed (*Sporobolus heterolepis*) gave somewhat similar results, but little bluestem (*Andropogon scoparius*) intercepted from 50 to 60 per cent. of the water applied at the rate of one-half inch in 30 minutes. In low prairie, composed chiefly of big bluestem (*A. furcatus*) and tall panic grass (*Panicum virgatum*), with flower stalks fully developed, the interception at different rates of application was one inch in an hour, 47 per cent.; one-half inch in 30 minutes, 57 per cent.; one-fourth inch, 67 per cent.; one-eighth inch, 81 per cent. for similar periods. Bind weed (*Convolvulus arvense*) intercepted 17 per cent. of water applied at the rate of one-half inch in 30 minutes, 30 per cent. when one-fourth inch was applied, and 50 per cent. when one-eighth inch was used. For buffalo grass (*Buchloe dactyloides*) the results were: one-half inch in thirty minutes, 31 per cent.; one-fourth inch, 46 per cent.; and one-eighth inch, 74 per cent. In all the experiments it was found that wind, through its influence upon evaporation, had a marked effect upon the percentage of interception.

Results thus far obtained show that the amount of water held upon the surfaces of leaf and stem and prevented from reaching the soil is very great. They clearly show that the amount of water thus held depends largely upon the rate at which the water falls and, to a certain extent, upon the environmental conditions, especially wind movement. In the plants studied, little water ran down the stems and thus reached the soil. So far as use to the vegetation is concerned, the water intercepted represents a loss, which over large areas becomes enormous. For example, when a thick growth of bindweed intercepts 13 per cent. of one-half inch of water in 30 minutes, the amount withheld by the plants from reaching the soil is 7.5 tons per acre. Wheat in intercepting 52 per cent. of a similar rainfall causes a loss of over 29 tons of water. When an inch of water falls during an hour, buffalo grass intercepts over 28 tons per acre, while prairie composed chiefly of big bluestem may intercept as much as 53 tons per acre.

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RENEWAL OF MULTIPLE PRECIPITIN PRODUCTION ON INJECTION OF ONE ANTIGEN IN RABBITS SUCCESSIVELY IMMUNIZED WITH MANY ANTIGENS

FIFTEEN antigens,[1] adsorbed on aluminum hydroxide,[2] were injected one by one at intervals of about seven days into the muscles of two rabbits. The amounts injected varied from 7.5 to 25 cc of aluminum hydroxide, the antigen strength of which was 1 per cent. Before each injection the blood serum, except in two or three instances, was tested for precipitin for the antigen about to be injected and for precipitins for the antigens previously injected. The first injection was made on January 8 and the last on May 23, 1936. There was good precipitin production in response to all the antigens except the last three injected, namely, human hemoglobin, Bence-Jones protein and beef lens. So far as indicated by the tests the injections of antigen did not reduce the precipitins in the serum for antigens previously introduced, but as no tests were made before seven days after each injection, the possibility of an earlier fall in the content can not be excluded.

Following the last injection in rabbit 1 precipitin after precipitin disappeared from the serum. On October 27 no precipitins were demonstrable, but in February, 1937, the tests for ovalbumin, human albumin and beef pseudo-globulin were positive. On February 23 10 cc of a 1 per cent solution of ovalbumin in salt solution were injected intramuscularly, and during the next few weeks five precipitins which had been absent for several months reappeared in the serum.

In rabbit 2 the precipitins disappeared more slowly. On March 23 tests were obtained for six precipitins. On March 24 15 cc of 1 per cent. solution of Bence-Jones protein 1 were injected intravenously, and during the next week the serum reacted with all the antigens that had been injected previously.

[1] Ovalbumin, human albumin, beef pseudoglobulin, human pseudoglobulin, beef albumin, horse pseudoglobulin, chicken blood albumin, Bence-Jones protein 2, dog albumin, hog thyroglobulin, beef hemoglobin, guinea pig serum, human hemoglobin, Bence-Jones protein 1, beef lens. The two Bence-Jones proteins used are different antigenically.

[2] Hektoen, Ludvig and Welker, William H. Precipitin production in rabbits following intramuscular injection of antigens adsorbed by aluminum hydroxide. *Jour. Infect. Dis.*, 53: 309, 1933.

SUMMARY

Multiple precipitin formation may be induced in the rabbit by the successive introduction of different antigens, and many precipitins may exist simultaneously in the blood for some time. Precipitins no longer demonstrable in the blood of a rabbit subjected to multiple successive immunization may reappear on the injection of only one of the antigens previously injected. Whether an unused antigen would have the same effect has not been determined.

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CATALYTIC REDUCTION AND DEACETYLATION OF THE METHYL ESTER OF HEXACETYL "β"-METHYLALDOBIONIDE TO 6-GLUCOSIDO-β-METHYL-GALACTOSIDE

THE methyl ester of "β"-methylaldobionide, from gum arabic, was acetylated and the new crystalline hexa-acetate

(having m.p. = 140°, $[\alpha]_D^{23} = -54.3°$ (in acetone)
and the following composition:
Found: C 49.24, H 5.8, OCH_3 10.01, $COCH_3$ 40.96
$C_{26}H_{36}O_{18}$
requires " 49.04, " 5.7, " 9.75, " 40.57)

has been reduced and deacetylated in methyl alcohol solution in an atmosphere of hydrogen, in the presence of copper chromite catalyst, at a temperature of 175° and pressure of 3,600 pounds per sq. in. during 5 hours. The product obtained was quite free from uronic acid (naphthoresorcinol test) and had the following composition:

Found: C 44.25, H 6.9, OCH_3 9.84
$C_{13}H_{24}O_{11}$ requires " 43.80, " 6.8, " 8.71

It had $[\alpha]_D^{25} = -61.6°$ (in water), thus indicating that the product is probably the β-methyl-glycoside of 6-glucosido-galactose.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

ON SECURING LARGE QUANTITIES OF DIATOMS FROM THE SEA FOR CHEMICAL ANALYSIS[1]

A KNOWLEDGE of the chemical composition of marine diatoms is desirable because of the essential role these organisms play each year in the constructive part of the food cycle of the sea and because of the importance diatom substance may have had in the formation of petroleum deposits. Although countless billions of diatoms may exist in small areas of the ocean, their minute size makes it extremely difficult to obtain any considerable quantity. Chief among the difficulties encountered are the very large volumes of water which must be strained and the rapid clogging of the filtering surfaces by the diatom cells. During the past summer at the Woods Hole Oceanographic Institution methods of circumventing these difficulties were explored.

The use of a large silk net towed from a boat was found more effective than the pumping method,[2] provided that the proper size mesh was selected for the type of diatoms desired. Another method, consisting of culturing a pure strain of diatoms on a large scale, is on trial by Mr. Bostwick Ketchum at the Harvard Biological Laboratories. However, exceedingly few species have been cultured successfully by any one. The advantages of procuring the diatoms directly from the sea are that any types occurring in great abundance (and hence important in the economy of the sea) can be obtained, that large quantities are procurable within a short time (at least six nets could be used simultaneously from a boat), and, since no danger exists of changes due to artificial conditions, the chemical constitution of the organisms secured will be as in nature.

To permit any useful interpretation of the chemical analysis of the material obtained, a certain degree of purity of the catch is required. If particles of detritus or protozoans *of the same size* as the diatoms are abundant in the water, it is obviously impossible to obtain a large quantity of uncontaminated diatom material by simple straining. Another time or place must be sought. In cases in which the detritus is very finely divided, it can be avoided by the use of the coarsest net which will retain the diatoms. However, copepods or other crustacea are almost sure to be encountered, and, because of their larger size, even small numbers of these animals would be a serious contamination quantitatively. Success in excluding organisms larger than diatoms was attained through the use of a cone of coarser silk placed over the mouth of the net and towed apex foremost. The mesh of this

[1] Contribution No. 164, Woods Hole Oceanographic Institution.

[2] However, pumps or sea-cocks have been found useful for collection of plankton in smaller quantities. *Cf.* L. D. Phifer, SCIENCE, 79: 298, 1934.

cone was of such a size (No. 0 silk = 38 strands per inch) that the diatoms could pass freely through it, but copepods, etc., were stopped and swept off to one side.

Using one net (1 m diameter, 4 m long, No. 10 silk = 109 strands per inch) provided with a cone of this type, large quantities of diatoms were obtained on two occasions during September in Vineyard Sound. The net was towed at very slow speed, and at intervals of three minutes was hauled in and emptied. Each catch, which amounted to about six quarts of a thick suspension, was allowed to stand for two half-hour periods. At the end of each period the supernatant liquid, in which the diatoms remained suspended, was poured into a strainer, leaving in the bottom of each jar the heavier sand, detritus, and whatever zooplankton had accidentally entered. In the strainer (a bag of No. 20 silk) the material drained in the course of about half an hour to a sludge. For the first day's work, this sludge was spread out on towels to dry, and later transferred to a chemical hood heated to 40° C. On the second occasion the sludge was not dried but was shaken immediately with an equal volume of ether. As a result of a day's work we obtained on the first occasion about 200 grams of dry, flaky material, and on the second occasion about two quarts of sludge in ether.

A complete analysis of the plankton in a sample of sea water taken during the first operation, kindly carried out for me by Miss Lois Lillick, showed that the concentration of diatoms in this area was almost 200,000 cells per liter. This approaches the maximum richness observed for diatom flowerings. One species of diatom (*Rhizosolenia alata*) composed 85 per cent. of the count, another species (*Corethron hystrix*) formed 8 per cent., and seventeen other forms together amounted to less than 7 per cent. Examination of a sample of the sludge indicated that the detritus and the animal contaminants were as low as ever found in phytoplankton hauls, in this case being certainly less than 1 per cent. of the total volume. All the material has been turned over to Professor Hans T. Clarke, of the Department of Biological Chemistry at Columbia University, for chemical analysis.

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A COLOR TEST FOR THIAMIN (VITAMIN B_1)

A FEW milligrams of thiamin (crystalline, synthetic, Merck) and about five milligrams of p-dimethylaminobenzaldehyde are placed in a small crucible. 0.1 cc of glacial acetic acid is added and the mixture heated until all the acid is evaporated. After cooling, one drop of glacial acetic acid is added. An intense brick red color develops immediately.

The red compound is probably a Schiff's base, as most primary amines readily form colored condensation products with aldehydes.[1] Proteins and amino acids interfere.

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A METHOD FOR OBTAINING NEWLY HATCHED TADPOLES IN A CLEAN STATE

IN removing newly hatched tadpoles from their egg mass, especially when this has been procured outside the laboratory, some difficulty in obtaining them perfectly free from their "jelly" is often encountered. To overcome this the following procedure is suggested.

Place the material—the egg mass, if the larvae haven't hatched as yet, or the mixture of animals and debris—in as small a dish as convenient. Set this in a second container of sufficient size to enable water in it to more than cover the first vessel. Slowly fill the larger with clean water, being careful not to disturb the material in the smaller dish as the water overflows into it. Enough water to cover the dish by about three eighths of an inch should be added, and allowed to stand undisturbed. As soon as they are able, the tadpoles will rise and leave the smaller dish, entering the clean water surrounding it, from which they may be easily removed by means of a pipette.

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[1] O. Frehden and L. Goldschmidt, *Mikrochim. Acta*, 1: 338, 1937.

BOOKS RECEIVED

KENOYER, LESLIE A. and HENRY N. GODDARD. *Laboratory Manual for General Biology.* Pp. 73. 27 plates. Harper.

Les Classiques de la Découverte Scientifique: J. B. DUMAS. *Leçons de Philosophie Chimique.* Pp. xxviii + 270. 2 plates. LAVOISIER. *Traité Elémentaire de Chimie.* Pp. xxxviii + 191. Illustrated. WÖHLER. *La Synthèse Totale en Chimie Organique.* Pp. viii + 143. 8 plates. Gauthier-Villars. 21 fr. each.

MAURAIN, CH. *Étude Pratique des Rayonnements. Solaire, Atmosphérique et Terrestre. (Méthodes et Résultats.)* Pp. 188. 18 figures. Gauthier-Villars. 80 fr.

Skrifter Om Svalbard Og Ishavet, 1937: No. 68, HANS FREBOLD and E. STOLL, *Das Festungsprofil Auf Spitzbergen, III.* Pp. 86. 1 plate. *No. 69,* HANS FREBOLD, *Das Festungsprofil Aug Spitzbergen, IV.* Pp. 94. 11 plates. *No. 70,* EILIF DAHL, B. LYNGE, and P. F. SCHOLANDER, *Lichens from Southeast Greenland.* Pp. 76. I. Kommisjon Hos Jacob Dybwad, Oslo.

TODD, T. WINGATE. *Atlas of Skeletal Maturation.* Pp. 202. Illustrated. Mosby. $7.50.

Transactions of the American Philosophical Society, September, 1937. The Mammalian Fauna of the White River Oligocene. Pp. 155–269. 70 figures. 33 plates. The Society, Philadelphia. $2.00.